05 Exam 1 In Class

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You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]
   a. Sketch an “ideal” heating curve for the substance H₂O if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.
   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.
   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.
2. The famous “tilting bird” is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It’s not enough to say, “do this and it works”. You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot “do” anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call “the weather”. In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.
5. Some plastic kitchenware is “dishwasher safe” and some is not. It’s not about whether the stuff will dissolve, it’s about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

Each end and corner represents a C atom. For example, is

\[
\begin{array}{c}
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\text{H} \\
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\text{H} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{H} \\
\hline
\text{H} \\
\text{H} \\
\text{H}
\end{array}
\]

Type A looks like this:

Type B looks like this:

6. Ammonia is the substance NH₃. Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.
Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

Reason for choice:

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

Reason for choice:

9. Thermosensitive neurons, ONE of these statements is incorrect. Which is it?
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

Reason for choice:
10. An action potential in a nerve cell involves everything EXCEPT
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

   Reason for choice:

11. SKIP THIS ONE

   Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don’t have to provide an answer to that question.
The first exam helped me understand where you were individually with the ideas we’ve been discussing. Some people did very well, many were Ok to so-so, and some were weak. Some people were not able to finish every question. Given that I have given you few opportunities to show me your best individual thinking, I don’t want the results from this exam to be discouraging. So, instead of just returning a graded exam, I’m going to give you a second chance at some of the questions in the form of a homework assignment. I will make a correction to your original score (which you still don’t know). It won’t be a complete do-over, but I will acknowledge improved responses.

To give you some idea as to how you did, consider problems 1a, 1bc, 3, 4, 5, and 6. Out of these 6 things, your answers convinced me that you substantially “got” the idea in $X$ of them. For everyone in class, the range was 1 to 6, median of 4.

I encourage you to try to use only resources available from the course, from Blackboard postings of links, readings, or from your class notes. Obviously, I can’t stop you from consulting other people or resources, but your understanding will be stronger if you try to rely on your own resources. You also may have better ideas now because of other things that have happened in class.

So, attached to this is a blank exam. All questions except 2 and 11 are eligible for answering for this assignment.

9 and 10 – I had made a mistake on these. I had intended to say “all of the choices are correct EXCEPT”. So, treat these as “brand new” questions, because asking you to look for the INCORRECT statement changes the sense of the question and your potential explanation. The new copy of the exam has a changed wording.

This assignment is due the Tuesday class after break.

-------- next is a subsequent message--------

I’m not changing the assignment, just refining the instructions and telling you how the scoring adjustment will work. Still due by Thursday’s class.

You have a blank exam to treat as a homework assignment. You have the opportunity to re-think and rewrite each of the questions. Even if you had a good grasp of the question the first time around, having this opportunity is going to strengthen your understanding of the ideas.

All questions may be answered, except for #2 and #11. I’ll show you Tuesday and explain how the bird works. But I gave you a clue last time – the bird will tip if you soak its head in water. And many of you had the right idea that a pressure difference develops between the bottom bulb and the top bulb. See if you can figure it out – it’s based on all the principles we’ve dealt with in class. I discussed how it works with some people already, so that’s why I’m not including this question.
You can handwrite the answers, or type the parts you can, but I want a physical copy in any case.

When you turn the exam homework in, I will give you your scored exam back (if you promise not to show it around to the others). I will score the homework fresh without looking at your first exam. Then I will calculate the average of the two scores (original exam and homework), and that will be your adjusted exam score. I am still happy to have you visit me if you want to talk through answers afterwards.

Special situations:

- The last two questions have been changed in their focus, so they are not the same as before. The score I give you on these will not be averaged – the score will be just based on the homework assignment. This may result in loss of some points, but I think this is fairer than averaging – everyone is in the same boat then.

- If you didn’t even attempt a question the first time, I will let your redone assignment count three times as much. So, if you get a 8/10 the second time for a problem you left blank the first time, your adjusted score will be 6/10, not a 4/10.
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]
   a. Sketch an "ideal" heating curve for the substance H₂O if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.
   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.
   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

At 0 °C the water goes from a solid to a liquid. At 100 °C the water goes from a liquid to a gas. The slope changes at each phase change because there is no kinetic energy being added. The energy is going towards breaking apart the bonds of the molecules. So temperature is held constant as this energy breaks the bonds. Heat is involved because you need heat for these phase changes to happen. Heat gives energy to the molecules which lets the molecules break apart. Taking heat and therefore energy away from the molecules would cause a downward slope.

If the molecules are less attracted to one another, the freezing point and the boiling point will be lower. Since there is less attraction between the molecules, there will be less energy needed to break them apart so the gas phase will come sooner. It also means that it will take longer for them to bond together so the point at which the molecules become a solid is going to be colder.
A heating curve for dry ice is unique because dry ice undergoes sublimation, or a direct phase change from solid to a gas, while most substances will have two points where their curves even out as they undergo a phase change because they have 3 states, dry ice only has this one point because it only has two states, a solid and gaseous state.
2. The famous “tilting bird” is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It’s not enough to say, “do this and it works”. You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot “do” anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

a) My explanation as to why this occurs is there is two different liquids in the bird. The bottom bulb has a warm liquid and it is sealed off from the middle thin pipe which has mercury in it like a thermometer. The “warm” liquid makes the mercury rise, which makes the bird tilt because the bird is then top heavy, when the bird gets completely horizontal the mercury shrinks because it is no longer touching the warm liquid and the process restarts.

b) To test this you could put a liquid that is colder than the mercury in the bottom bulb and see what happens.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call “the weather”. In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected? The air in the clouds is going to become denser and water will build up in the clouds until it rains. The air towards the ground is dense because there is so much energy in the air molecules they are very spread apart. As the air rises and the temperature drops, these molecules lose energy and they start to compact back together. The air goes from being not so dense because the molecules are far apart, to dense because they are forming back together. As the molecules lose energy, the air becomes cooler and cooler because heat is energy. Eventually, the air will undergo a phase change and become a liquid and this will form in the clouds. This is why it is colder in places where there is water because as water evaporates and the molecules lose energy, the air gets cooler.

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.

Most metals expand when temperature rises because volume is directly proportional with temperature. When the temperature rises, average speed of the molecules increases. This increased speed leads to more frequent and more forceful collisions between the molecules. With increased kinetic energy, the molecules will make a more forceful impact with the inside of the metal and the metal will expand. This is the same with liquid. The more forceful collision causes the bonds between the molecules to break apart and it expands. When energy is taken away, in both instances, there is less kinetic energy between the molecules and there is less collisions and less forceful collisions, so the metal and the liquid will contract.
5. Some plastic kitchenware is "dishwasher safe" and some is not. It's not about whether the stuff will dissolve, it's about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

Each end and corner represents a C atom. For example, \( \text{\_\_\_\_\_\_\_\_\_} \) is \( \text{H}\quad \text{H}\quad \text{H} \)
\[ \begin{array}{c}
\text{\_\_\_\_\_\_\_\_} \\
\text{H-C-C-C-H} \\
\text{\_\_\_\_\_\_\_\_} \\
\text{H\quad \text{H}} \\
\end{array} \]

Type A looks like this:

Type B looks like this:

I think type A is dishwasher safe. I think a carbon - carbon bond is stronger than a carbon - hydrogen bond. Type A is primarily made up of carbon - carbon bonds because each end represents a carbon and the lines connect end to end. Type B has the ends of some lines connecting to the middle of others and I think that is a weaker bond. It will take less heat energy to break the weaker bonded type B than stronger bonded type A, so I believe type B will melt.

6. Ammonia is the substance \( \text{NH}_3 \). Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.

<table>
<thead>
<tr>
<th>Solid</th>
<th>Liquid</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Solid Diagram" /></td>
<td><img src="image2.png" alt="Liquid Diagram" /></td>
<td><img src="image3.png" alt="Gas Diagram" /></td>
</tr>
</tbody>
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Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

Reason for choice: d is the right choice for numerous reasons. One, we don't know the atmospheric condition of the planet. We learned that air pressure at higher altitudes can affect the energy needed to break the bonds of the molecules in a substance. Absolute zero will always be the same because at some point there will be no more energy left in a particle and that temperature won't change even in different atmospheric conditions.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

Reason for choice: You want to use a liquid that won't freeze or turn into a gas. For that reason you want a liquid with a low melting point, which means a low freezing point and a high boiling point. Essentially you want a liquid that has the largest difference between melting and boiling point so it will stay a liquid.

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

Reason for choice: When we talked about gum & peppers, we discussed this. When you chew gum, your mouth feels cold. The gum itself isn't cold, but the chemical menthol in the gum acts as a stimulus on the cold thermal receptors on your tongue, which sends signals up the afferent tubes to the hypothalamus. The hypothalamus synthesizes the information and at that point we perceive the gum as being cold until there is no more action potential and the neuron goes back to resting potential.
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

   Reason for choice: we learned that when different ions move across the cell membrane, these ions will cause the neuron in the cell to switch from negative to positive and this will cause the neuron to go from resting potential to action potential.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don’t have to provide an answer to that question.
1. You conducted experiments with heating and cooling curves. [20 pts]

   a. Sketch an "ideal" heating curve for the substance \( \text{H}_2\text{O} \) if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.

   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water's. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.

   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

\[ \text{H}_2\text{O} \text{ at } -40 \degree \text{C would be in the solid phase and seen as ice. As heat is added over time, the temperature would increase, when the ice began to melt, the temperature would remain constant at the melting point, until all of the solid melted into liquid water. Once the phase change occurred, the temperature would begin to increase again until the water began to boil (100 \degree \text{C}). The temperature would then remain constant until all the liquid turned into a gas and then the temperature would continue to increase. This constant temperature during the phase transition is known as latent heat.} \]

\[ \text{b) If the molecules of a substance are not as attracted to each other as the molecules in water, then this is a factor that will affect phase change. The molecules in water have stickiness because they are really attracted to each other. A substance whose molecules have less stickiness will have a lower melting point and boiling point. This is because it requires less thermal energy to lessen the attraction between the molecules. We saw this with water and oil on wax paper. The water molecules were attracted to each other and formed together where the oil did not have nearly a higher melting point than oil.} \]

\[ \text{Sublimation is also an example of latent heat because the temp will remain constant until all of the solid has turned to a gas, then continue to increase temp.} \]

Dry ice is solid carbon dioxide. When placed in a syringe, a solid (about 1 mL) piece of dry ice will sublime to about 100x its volume. Sublimation is going from the solid to gas phase. It is easier for dry ice to undergo sublimation than evaporation. This is because it is hard to obtain dry ice as a liquid since pressure of its triple point is so high. When dry ice is exposed to room temperature, it will sublime to a gas as we saw in the science. The molecules become more spread apart and the volume increases.
2. The famous “tilting bird” is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It’s not enough to say, “do this and it works”. You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot “do” anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

(a) There is a red liquid inside of the tilting bird. One bird is not tilting and all of the liquid is sitting at the bottom of the bulb. The other bird is tilting over and over. The liquid in this bird continues to rise up the bulb making the top of the bird heavy and then it tilts. Once it tilts the liquid flows back to the bottom of the bulb and the process keeps continuing. You can see condensation forming on the inside of the tube on the bird that is not tilting. Condensation releases heat to the environment as a gas turns to a liquid and the environment is increased in temperature as a result. If condensation is occurring inside the tube, the molecules in the surrounding air would be increasing in speed and becoming more spaced out. As the volume of the air increases, the bird could be caused to tilt as the liquid becomes less dense than the air than the air and rises. The rising liquid would cause the continuous tilting process to begin that we can witness in the second bird.

(b) We could test out this explanation for the tilting bird with an experiment where we calculate the density of the air and the liquid in the tube of the tilting bird. Density = Mass / Volume.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call "the weather". In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

   If the air mass is forming into water then it is undergoing a phase change from a gas to a liquid. This phase change is called condensation and releases energy to its environment. Since energy is being released as condensation occurs, the surrounding air in the clouds would be affected because it would have a temperature increase. This is the same idea behind why steam burns are more harmful than boiling water. When a gas turns to a liquid, the environment is heated because energy is being released. Since the surrounding air in the clouds would be gaining energy and increasing temperature, the molecules would speed up as well as move more rapidly and for apart.

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.

   An increase in temperature (such as adding heat) will affect the molecules in a substance even in absence of a phase change. When the temperature increases, most metals and most liquids won't undergo a phase change but the molecules of the substance will still move faster and more spread out. The temperature increase causes an increase in kinetic energy. As the molecules spread out and increase velocity, the volume will be increasing and that is why the liquids and metals would expand.
5. Some plastic kitchenware is "dishwasher safe" and some is not. It's not about whether the stuff will dissolve, it's about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

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</table>

Type A looks like this:

Type B looks like this:

Structure and packing have an effect on phase change. For example when we compared stearic acid and oleic acid, stearic acid had a much higher melting point of about 76°C while oleic acid had a melting point of 18°C. Stearic acid has all single bonds while oleic acid has a carbon-to-carbon double bond which created a kink. This kink made it hard for the molecules to pack together correctly and therefore oleic acid has a low melting point. Based on this, I would assume Type A would be dishwasher safe because it would have a higher melting point than Type B. Type B looks like it would have a low melting point because of kinks in its packing which would make it easier to

6. Ammonia is the substance NH₃. It loosens the attraction between molecules and would make it not dishwasher safe.

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.
Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
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Reason for choice:

**Absolute zero is equal to 0 Kelvin. This is the temperature where no more energy can be taken from a system and all motion has stopped. We saw the molecules on the PhET simulation stop moving when we reduced the temperature to 0K. Since absolute zero is the lowest temperature where energy still exists I would predict that the temperature of absolute zero would be the same on another planet.**

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

Reason for choice:

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   Reason for choice:

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don’t have to provide an answer to that question.
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]

   a. Sketch an "ideal" heating curve for the substance H₂O if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.

   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water's. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.

   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

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A) Heat is constantly being added, otherwise as a constant it is represented as time (x-axis). There are two phases changes present for H₂O, at -40°C the Melting point, and at +100°C the boiling point. At both points the temperature stabilizes, for a period of time, even though heat is still entering the system at the same constant.

B) If you were to take methane for instance (CH₄) very close in molar mass to H₂O, because of the lack of polarity, we probably already missed both phase changes. My guess without Wikipedia is that by -40°C, it is already a gas and would therefore look like a constant increase of temperature.

C) Port C on back
C) Of the top of my head (which may or be right) dry ice sublimes at -213°C. For this reason there would only be one phase change (neither A-P or P-L). At this phase change CO₂ would change directly from a solid to a gas. I would assume that if you could increase the pressure enough, that would be different and you could get it to melt and then boil, but not at 1 atm.
The famous "tilting bird" is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It's not enough to say, "do this and it works". You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot "do" anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

Bird A - does not move
Bird B - does

The liquid in Bird B rises much like a Hydrometer.

The exterior pressure must be less than that in the bulb.

The movement is produced by weight distribution. As the liquid moves up the cylinder it becomes more and more top heavy and begins to occlude until there is not enough pressure in the bottom bulb. Pressure is then released because of gravity and the liquid returns back to the bottom. The weight at the bottom swings like a pendulum and allows the process repeats allowing the motion to continue.

If you hold Bird B still you can still witness the liquid climb. However, the liquid in Bird A must be different and does not respond to the atmospheric pressure. The pressure in the bulb must be lower than that outside.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call “the weather”. In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

Water droplets because of their high polarity caused by hydrogen bonding will begin to stick together and gather, essential the droplets will join and become bigger and bigger until the droplets are big enough to fall without evaporating and this will cause rain.

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.

As temperature rises, most metals and most liquids expand because of the increased kinetic energy into the system. As a molecule is heated, energy transfers into the molecule increasing its speed. As the molecules increase in speed the force their impact exerts on their container will either cause the pressure to rise, or the container to expand.

However in the solid state, or liquid state the force is not so much being exerted on the physical container, but the attractive forces of the molecules. The solid will expand as the kinetic force is pushing outward until its potential energy is greater than the attractive force holding it together; this will cause a phase change.
5. Some plastic kitchenware is “dishwasher safe” and some is not. It’s not about whether the stuff will dissolve, it’s about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

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Type A looks like this:

Type B looks like this:

Type A is dishwasher safe. The reason will be sticking because of its uniformity type A will stack better creating a much stronger substance. Type B will not stick well and therefore will have a much lower MP.

6. Ammonia is the substance NH₃

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.
Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

   Reason for choice:
   **Absolute temperature is fixed, whereas the MP's of H₂O, Hg depend on pressure.**

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

   Reason for choice:
   **High and low are relative, you would however want enough of a distinction between mp and bp so as to give you an absolute measurement but you would want them close enough together to ensure replicability of the instrument.**

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

   Reason for choice:
   **All of these were discussed and then we came together as groups and discussed certain topics using all of this information.**
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

   Reason for choice:
   Action potential is caused by the polarity in the neuron changing, not or less by the exchange of K⁺ ions for Na⁺ ions.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don't have to provide an answer to that question.

   I was prepared to respond to anything!
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]
   a. Sketch an “ideal” heating curve for the substance H₂O if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.

   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.

   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

   As heat increases, the H₂O goes from a solid, to a liquid (at the melting point (0°C)), and from a liquid to a gas (at the boiling point (100°C)).

   The plateau'd portions illustrate the H₂O being in that particular phase where the incline represents the transition between phases.

   If a substance had a weaker attraction between molecules, it would have a higher freezing point because it would take more energy to condense the molecules. It would also have a lower boiling point because the molecules would have an easier time spreading out and would break less bonds to go from liquid to gas.

   Dry ice has a very low freezing point, but at room temperature it is a liquid, since when we put it on the table it was like water, but too cold to touch and then it evaporated into gas. It is able to not become a solid until very low temperature.
2. The famous "tilting bird" is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It's not enough to say, "do this and it works". You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot "do" anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

I believe that the bird tips over and over because there is pressure in the tube at the bottom, and since temperature is constant volume needs to change, so some liquid gets "sucked" into the tube to relieve the pressure in the system. As more liquid is added into the long tube, the weight begins to tilt the bird until all of the pressure is removed and then the pressure inside the bulb is less than that in the tube so the liquid goes back into the bulb and starts over again. The area with more liquid has generated more pressure because a constant temperature and volume increases pressure, and the tilting motion back and forth is the system regulating itself to be more balanced. An experiment to test this would be by determining if pressure actually was the cause of this. With an increase in temperature, pressure should increase as well (so if the birds were put in a higher temperature area (more pressure) and a lower temperature area (low pressure) the variable of pressure would be isolated as the cause. The hope would be that birds in a high temperature move more quickly because there is more pressure, and that the colder birds would move slower.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call “the weather.” In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

The air in the clouds is less dense than that of the warm (denser) air near the ground, which means that the particles are not as tightly packed, and they are in the liquid form. The air will be thinner in a cloud because the molecules will have more kinetic energy that was absorbed over the course of the day, thus making particles move quicker and take up more space. This explains why on a cloudy day the air is usually colder, both because the sun may be covered but also because heat on the ground has been absorbed. The air in clouds is usually thin and when temperature is warmer, clouds will have molecules that move even faster, causing clouds to be more spread out and thinner. They may also appear lighter in color, more transparent. The big white fluffy clouds are more dense with more molecules moving at a slower pace.

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.

Most metals and liquids expand when temperature rises because when temperature rises, or when heat is added, the kinetic energy in a substance is increased, making the molecules move more quickly with more energy. In the case of a liquid, when temperature increases, so does kinetic energy, so does the volume, because the amount of pressure in the situation needs to be fixed, or stay the same in order for the substance to stay in that state of matter. Liquids take the shape of whatever container they are in, and their molecules are not as tightly packed, resulting in more expansion, and less energy required to do so. Solids, such as metals, are bonded much closer together, resulting in more energy being needed to expand, and upon expansion it won’t be as dramatic as a liquid. Anytime temperature increases, more kinetic energy is being added to the system, resulting in more freedom and movement of the particles and at a constant pressure, the volume will increase. When energy is added the pressure and volume are affected, if the constraint is on pressure, making it constant volume is left to increase.
5. Some plastic kitchenware is “dishwasher safe” and some is not. It’s not about whether the stuff will dissolve, it’s about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

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Type A looks like this:

Type B looks like this:

I think type A is dishwasher safe because the atoms are more uniform and tightly bonded, thus making them sturdier. In a solid many of these configurations (above) are put together, and type A’s shape is more conducive to fitting them together. Type B’s shape is too abstract, and will leave too much space between molecules, thus making it less stable and more susceptible to the heat of the drying cycle. As heat increases these molecules will want to move and spread apart, and if they are packed closer together, they will vibrate more than move, and they will not melt.

6. Ammonia is the substance NH₃

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.
Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

   Reason for choice:
   The ratio would be the same because whatever affected the melting point in one substance (pressure, temp, etc) would have an effect on both ice and mercury. The ratio would be the same. For example, how we could calculate the melting point on another plant now with some give information. But the ratio to the absolute value on the planet would be the same.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

   Reason for choice:
   If you have the lowest melting point and highest boiling point you will have the biggest range, and it would have the most universal use.

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

   Reason for choice:
   There are fast twitch heat receptors and slower twitch cold receptors. There are two different kinds because the body responds to cold and heat separately, although they are ultimately processed in the same way.
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

   Reason for choice:
   An action potential is the amount of potential energy in a substance or neuron and once the stimulus has been activated, that energy is sent down the membrane and sent through the body or for a certain function. This energy is stored and built up ready for use. There is a difference in the voltage of the membrane and the signal travels up and down the membrane until it is acted on, in the form of a thermoreceptor for example.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don’t have to provide an answer to that question.

   I think it would be a good question to ask about temperature preference and some areas enhance the experiment we did where we put our hands in cold water or hot water and then room temperature. I think it would have been good to ask why this occurs and look into an explanation for how thermoreceptors adjust and react when placed at extremes. I think the idea of receptor sensitivity and sensation versus perception of hot versus cold is a good question to ask because it lined up with what my group did when we explained the “cooking” with a stick of gum. I think that concept of self regulation and adaptation is key to understanding how we react to hot and cold.
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]

   a. Sketch an “ideal” heating curve for the substance H₂O if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.

   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water. See reverse side.

   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

   ![Heating Curve for H₂O](image)

   - **Liquid (water)**: The upward slopes of the graph indicate that temperature is increasing in the form of H₂O that is being examined (i.e., solid → liquid → gas). The platelike areas are where a phase change is about constant, and potential energy is increasing to help facilitate the phase change. The potential energy is adjacent, allowing for molecules to spread out. This allows the phase to change from solid → liquid, and/or liquid → gas. Heat is an integral part of this process, starting from ice, heat is added. This is demonstrated by the upward curve correlating the temperature aspect of the graph. As heat is added and temperature increases, the molecules move faster, in what appears to be a vibratory motion. The molecules are very close together due to bonds holding them in place. The bonds exist due to the polarity or charge of the molecules. H₂O is a very polar molecule, and molecules tend to stick together. This was exhibited in class with the experiment with the toothpick. The water bead would stick together and travel as the toothpick led its path. Next, we reach a point in the graph where the upward slope stops. This is because the temperature stops increasing. As the temperature stops increasing, the speed of the molecules stops increasing. This is known as kinetic energy which stops increasing. The energy now being increased due to the heat source is potential energy. The potential energy works to break the bonds between molecules apart, allowing there to be more space between the molecules. Slowly, the molecules spread out from being so attired, and a liquid is formed. This is the process of phase change. Temperature continues to rise, the molecules continue to increase speed. If same process explained above, repeats again (white working in higher temperatures) to allow the solid ice and more liquid to decrease.
phase changes that occur in this heating curve of H$_2$O.

I didn't leave myself enough room to do both lines on the graph, so I re-drew the graph below. The blue curve illustrates the heating of H$_2$O + substance—that is different from water. It has the same mass, but weaker polarity. This indicates that the bonds between molecules will break apart quicker. This means that it will take less time for each mass of same weight, phase change to occur, therefore the blue line shows that the temperature of 0°C + 100°C (freezing + boiling) are reached in a shorter amount of time: in minutes. This is because the phase change can occur in less time due to the bonds being broken with a requirement of less potential energy.

Heating of Dry Ice

This graph depicts sublimation. This is because when heated, dry ice goes directly from a solid to a gas. The process is similar to other phase changes illustrated in la. The change with this graph is seen in the fact that it takes much less time. This means the curves are less gradual. Since there is no liquid phase, there is also one slope missing compared to the first + second graphs. Only solid + gas phases are displayed.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call "the weather". In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you were talking about. As temperature rises, it is accepted that most liquids and metals usually expand. This is relating to the movement of the particles and the role of potential energy breaking bonds. As temperature increases, the speed of the particles increase. This is also known as kinetic energy, which is increasing. At this point, the solid is still a solid. At a certain point, the movement of the particles stops increasing as does the kinetic energy. The temperature stops increasing which makes the speed stop increasing, instead the energy that has a prominent role is the potential energy. The potential energy works to break the bonds. The old (metal) is preparing for a phase change through the increasing potential energy. The potential energy works to break the bonds which are holding the molecules which comprise the piece of metal together. As more and more of the bonds begin to break, the molecules are allowed to let there be more space between them. This is because the bonds are not holding them close together any longer because the bonds are not holding them close together any longer. The metal has increased in space is what makes the metal expand. The metal doesn't necessarily have to turn into a complete liquid. But if it does not necessarily have to turn into a complete liquid, then liquids are working towards becoming a gas. As temp + kinetic energy ↑, there comes a point when the focus is on potential energy → accumulated potential energy ↑, more bonds are broken →
and there is more space between the molecules allowing the liquid to expand to a greater volume.
2. The famous "tilting bird" is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It's not enough to say, "do this and it works". You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot "do" anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.
5. Some plastic kitchenware is "dishwasher safe" and some is not. It's not about whether the stuff will dissolve, it's about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

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Type A looks like this:

Type B looks like this:

6. Ammonia is the substance NH₃. Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.

Solid | Liquid | Gas

[Diagrams of solid, liquid, and gas states of ammonia]
Multiple Choice plus Explain  [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

Reason for choice:

No Matter where in the universe, the temperature of absolute zero is always going to be the same. Absolute zero is the point at which there is no movement, heat, or energy. At this point, it is unattainable. The notion of absolute zero is a uniform idea. It cannot be obtained at different temperatures.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

Reason for choice:

You want a liquid for the thermometer to be useful. If there was a low melting point, the liquid in the thermometer would be in a liquid state at cold temps. You also want a high boiling point because you want it to be hard to make the substance turn to gas. The melting point and boiling point allow the greatest range in temperature at which something could remain a liquid, so you need the substance to stay liquid in order to be a functional thermometer.

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

Reason for choice:

I remember reading about this in class. Also remember students discussing it on their posters, here are different receptors for both cold and warm temperatures. Thermoreceptors sense heat and follow along a pathway that is similar to cold receptors in the PNS and PNS systems. I cannot recall the names of the specific receptors or pathways, but I remember Jamie Sidney specifically mentioning them. This is also exhibited by some students presenting hot sensations (pepper) versus others (mint).
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

Reason for choice:
   Action potential in nerve cells is related to K⁺ and Na⁺ ions that move in and out of a cell via a sodium-potassium pump. This allows the message to propagate along the nerve pathway to the hypothalamus in the brain and back to the periphery where it (assume in this question) originated. I know this from our readings, class discussion, as well as taking Anatomy and Physiology as well as other medical courses.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don’t have to provide an answer to that question.

   My question would be regarding the speed of molecules in relation to their mass.

   Question: Would the molecules weighing 0.0001g or 0.00001g move faster if both were in the liquid state?

   This is a good question because it addresses the speed of molecules in relation to their mass. This was exemplified by one of the pithet simulations. I think it would be ideal to use specific molecules, but I do not know the specific weights of any molecules off the top of my head.
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]
   
   a. Sketch an “ideal” heating curve for the substance H₂O if you start with the substance at a temperature of 40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.

   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.

   (back)

   Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

   - Heat is being added to water over a duration of time as seen in the graph. As the curve shows when a phase change occurs, the temperature doesn’t rise, it stays constant. Adding heat is adding energy, this leads to increased particle motion which eventually results in the breaking of intermolecular bonds and phase change.

   b. A substance with similar mass, but weaker attractions between its molecules will have lower melting/freezing points and also a lower boiling point. This is because less energy (heat) has to be added to “break” the bonds. The bonds help the molecules resist changes in structure— weaker bonds will break earlier & allowing phase changes to occur at lower temperatures than H₂O.

   =>
As seen from the graph, dry ice sublimes from a solid to a gas. Therefore there is no liquid phase. As dry ice is heated it molecules break free into a gas as a result of very weak bonds. This is similar to the experiment where the dry ice went from a solid to a gas in the syringe.
2. The famous “tilting bird” is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It’s not enough to say, “do this and it works”. You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot “do” anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

The birds which are tilting have a liquid within them which is expanding up the central tube until the bird becomes top heavy. It then tilts forward removing the liquid in the tube to allow it to flow out. This process keeps repeating. I think the bird which is not moving is vacuum sealed, thereby not allowing pressure to affect it. The moving bird contains a liquid which has a low boiling point allowing it to be affected by “room temperature” heat. I also think that the moving bird isn’t sealed. Therefore the atmospheric pressure forces the liquid up the central tube. Assuming the liquid in both birds is identical in substance and quality, I could test this by “unsealing” the still bird. I could also place the tilting bird in a pressure chamber, allowing me to vary the pressure exerted on it. Therefore if my theory is correct as in it. Therefore if my theory is correct as pressure increases the bird should tilt completely over in a faster cycle. I think the tilting bird is being affected by pressure since eventually the bird will stop when an equilibrium is achieved.
2. As we saw in our readings about the thermoscope, pressure affects the behavior of the liquid in the tube.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call "the weather". In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.

As energy (heat) is added to a substance, whether it be a liquid or a metal, the particle activity (motion) increases. Particles begin to move and "break away" from one another. As a result there is more "space" between the particles. The particle size stays the same, but there is now a larger "gap" between the particles. The same holds true for liquids. There are attractions between each molecule. Therefore as temperature increases, the molecules kinetic energy increases (along with momentum) allowing the molecules to move farther away from each other.
4. As molecules are heated they try to "break free" from the group which leads to expansion. For example as seen in the Phet simulation when a solid is heated it's structure alters and the molecules become less organized. This is because the molecules are building up kinetic energy in an attempt to break free, hence larger distances between molecules.
5. Some plastic kitchenware is “dishwasher safe” and some is not. It’s not about whether the stuff will dissolve, it’s about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

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Type A looks like this:

Type B looks like this:

I think type A is dishwasher safe because its structure allows the molecules to “pack” together. We learned that two factors affect melting point and boiling point: 1) packing (how well the molecules fit together), 2) stickiness (the strength of the bonds). As seen in the illustration, type A will fit together better and therefore hold together better. Therefore more energy/heat will be needed to melt it, making it dishwasher safe.

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.
5. Type A will pack nicely with each other. Therefore the particles are in close proximity to one another requiring more energy to break the attraction to cause a phase change. Type B won't pack tightly, thereby nearing apart after a lesser amount of energy is added. Therefore type B will melt at lower temperatures preventing it from being dishwasher safe.
Multiple Choice plus Explain [5 pts each]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

   Reason for choice: A different planet could have different pressure which would affect a substance's melting or boiling point. The strength of the bonds with water and mercury probably vary. Therefore, the degree at which they melt relative to each other and absolute zero should be the same. The external conditions will affect each substance so the ratio should be the same.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

   Reason for choice: I chose c because a liquid with a low boiling point will respond better to small incremental changes in temperature. For example, a substance with a boiling point of 65°C will expand more when the temperature raises 5°C than a liquid with a 120°C point. A low melting point will allow low temperatures to be measured.

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

   Reason for choice: I chose b because that was the reading which was specifically assigned to my group. Although I remember discussing all of the choices, answer c our group created a poster on relating to hot peppers.
10. An action potential in a nerve cell involves:
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

   Reason for choice: I chose b because my group discussed how when a thermoreceptor is triggered there are substances such as K which move inside ⇒ outside or outside ⇒ inside. These transfers result in a chemical balance which relays the message to the brain—either cold or hot is being felt.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don’t have to provide an answer to that question.

   Explain why the triple point is located where it is on the phase change diagram.

   This would connect the the relationship between the three phases and pressure/temperature. Knowing this idea would display how each phase can occur at “abnormal” temperatures because of variations in pressure.
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]
   a. Sketch an "ideal" heating curve for the substance H₂O if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.
   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.
   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

   ![H₂O Heating Curve]

   While H₂O is in a solid state (-40 °C to 0 °C), heat enters the substance as kinetic energy increasing the temp of the substance and movement of the molecules. At 0 °C the H₂O begins to change phases (from solid to liquid) and thus absorbs the heat as potential energy (loosening the attraction between molecules so that they can break apart. Once the H₂O has melted to liquid, the heat is once again absorbed as kinetic energy. A phase change takes place at 100 °C and heat is then potential energy. Once the change to gas has been made, heat is once again absorbed as kinetic energy, thus causing a change in temp.

   ![Dry Ice Curve]

   Dry ice never becomes liquid; there is only one phase change that occurs—solid to gas. Because the point of sublimation is the only phase change that occurs, there is only one place in which the graph plateaus.
2. The famous “tilting bird” is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It’s not enough to say, “do this and it works”. You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot “do” anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

(a) It is observed that in the tilting bird the red substance is up a small tube in the center. As the bird tilts the substance rises. Once the substance has reached the top the bird becomes horizontal, the substance drains out the tube and the process restarts. The tube never seems to drop below half filled. The tube of the tilting bird feels cooler to the touch than that of the motionless bird. I would say that the action of the birds is either due to (a) the initial amount of substance in the tube. Perhaps once the tube is brought to half filled it causes the bird to become stuck in a pendulum-like swinging process.

Or the tilting is due to (b) the temperature or (c) type of substance in the bird. Perhaps the substance in the tilting bird is more reactive to heat, or has previously been in a cool environment. The change to a warmer environment could cause the molecules to become more active because of increased energy, thus causing the substance to rise up the tube and cause imbalance of the bird.

(b) a) To experiment this one could simply tilt the motionless bird enough to cause it to be half full and see whether it takes on the movement of the tilting bird.

b) Birds could be placed in different temperature environments and then brought into one environment and their different reactions could be observed.

c) Different substances with different heat reactivity could be placed in the birds.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call “the weather”. In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

Air in the clouds and cloud behavior is affected by the surrounding environment. Air rises because it is less dense. When the cloud air cools off enough, it condenses into water droplets thus becoming more dense which will then result in rain because the atmosphere cannot support the density. The height of the cloud, size, and ability to hold small water droplets depends on the surrounding environment. If the air is dense itself it can sustain clouds of greater density. Dry air and hot air cannot sustain clouds very well as water droplets are evaporated and distributed throughout the air to lessen the dryness thus preventing the molecules from gathering together to form clouds.

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.

Metals and liquids expand when temperature rises because of increased energy in the particles. The addition of heat gives molecules energy to loosen bonds with each other. Because attractions are loosened and molecules do not have to remain as tightly packed and organized as at lower temperatures.
5. Some plastic kitchenware is "dishwasher safe" and some is not. It's not about whether the stuff will dissolve, it's about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

Each end and corner represents a C atom. For example, is

\[ \begin{array}{c}
\text{H} \\
\text{H} \\
\text{H}
\end{array} \]

\[ \begin{array}{c}
\text{H} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{H}
\end{array} \]

\[ \begin{array}{c}
\text{H} \\
\text{H} \\
\text{H}
\end{array} \]

Type A looks like this:

\[ \text{Dishwasher safe} \]

Type B looks like this:

\[ \text{Not dishwasher safe} \]

and, lower the melting point of a substance. The melting point is lowered because the solid formation is not as easily achievable as those in type A. The branches of type B allow attractions to loosen more quickly and thus may result in this type of dish melting in the presence of heat and energy supplied by the dishwasher.

6. Ammonia is the substance NH₃

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.
Multiple Choice plus Explain [5 pts each]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

Reason for choice: Mercury and ice when placed under different atmospheric pressures may alter the individual melting point in relation to absolute zero. However, their ratio of melting points will remain the same because the molecules will remain the same and the change in atmospheric pressure from Earth to another planet will be the same. Because the change the substances have undergone are the same, their ratio will also be the same.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

Reason for choice: A liquid with a low melting point and a high boiling point would be unlikely to become solid or gas and thus alter the thermometer’s ability and effectiveness to properly relay the temperature of its environment.

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

Reason for choice: Capsaicin in chili peppers and certain ingredients in gum can trigger sensations of heat despite the fact that neither the chili pepper or gum is at a high temperature.
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

   Reason for choice:
   Sodium ions flood into the cell and potassium go out when an action potential is fired.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don’t have to provide an answer to that question.
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]

   a. Sketch an “ideal” heating curve for the substance H₂O if you start with the substance at a temperature of −40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.

   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.

   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

   In class I worked with graphing the heating and cooling of water. The curve slowly progressed in arch and upon reaching temperatures just above the 0-axis the curve leveled off. The temperatures then began to steadily increase in a slope. As heat is added to the water the temperature will increase. Heating the water takes time and therefore the graph shows changes in temperature over time. The line is sloped because factors like temperature and pressure could not be a definitive constant. If factors were constant when heating water the graph would appear as a straight increasing line:

   \[
   \frac{\text{Temp.}}{\text{Time}}
   \]

   The heating curve for a substance about the same mass as water, but with less attracted molecules would have the same general shape as the slope of water. However, it would take less time to heat that substance because the molecules will change more easily. Water has a very strong molecular structure as well as hydrogen bonds. These factors make it harder for water to phase change.
The heating curve for dry ice would look like this graph because it would take a significantly longer time to heat dry ice since it has such extreme low temperatures.
2. The famous “tilting bird” is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It’s not enough to say, “do this and it works”. You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot “do” anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.
Bird fitting takes red liquid up into tube.
When the box points down, the liquid drains from the tube.
When the bird stands upright again, the liquid is sucked back up the tube.
Other birds do not change.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call “the weather”. In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.

Most metals and most liquids expand when the temperature rises because the molecules spread out as they are heated. Molecules in the solid state are tightly packed together (紧紧) which means the substance as a solid would take up less space than a substance as a liquid or gas. Molecules in the liquid phase begin to spread out as they are heated because they are losing the structure of a solid. Liquid molecules would appear as (散散) this. If the substance continues to be heated the molecules will continue to expand as the substance changes state. A substance in the gas phase would have the most expanded molecules, which would be like this (散散散). Metals and liquids expand when heated because their molecules are no longer constrained to the solid phase, which has tightly packed molecules.
5. Some plastic kitchenware is "dishwasher safe" and some is not. It's not about whether the stuff will dissolve, it's about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

Each end and corner represents a C atom. For example, \[ \text{H} \quad \text{H} \quad \text{H} \]

\[ \text{H} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{H} \]

\[ \text{H} \quad \text{H} \quad \text{H} \]

Type A looks like this:

Type B looks like this:

Type B is dishwasher safe because it contains more carbon and hydrogen bonds than Type A. Hydrogen bonds are very strong and affect how easily a substance can be broken down or changed. For example, water has strong bonds because each molecule can contain up to four hydrogen bonds.

6. Ammonia is the substance \( \text{NH}_3 \).

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.
Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

Reason for choice:
Absolute zero is the lowest temperature that can be reached and it is a constant. Pressure and volume can affect temperature, but it would not change absolute zero. Absolute zero will always be the coldest temperature attainable.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

Reason for choice:
A liquid with a low melting point and a high boiling point would be best for a thermometer because it would be able to detect and rise or fall with very low or very high temperatures.

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

Reason for choice:
In class a group had made a poster about being in a sauna and being in ice water. The poster mentioned two different types of neurons that responded to the temperature.
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

   Reason for choice:
   In the packet on Action Potentials, the examples of calcium and potassium were used to describe how action potentials occur. As calcium and potassium flowed into or out of the cell, it initiates action potentials.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don’t have to provide an answer to that question.

   Draw a phase diagram and explain the triple point.

   This would be a good question because the phase diagram shows phase change of solids, liquids, and gases all in relation to each other. It sums up a large theme of this class, phase change, in one picture. It would be a good question to ask about the triple point because the triple point is an interesting occurrence and it should be something to know. I did not know about the triple point before this class and I think it is valuable information.
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]
   a. Sketch an “ideal” heating curve for the substance H₂O if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.
   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.
   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

\[ \text{Temperature (°C)} \]
\[ \text{Heat added} \]

\[ \text{solid (ice)} \]
\[ \text{liquid} \]
\[ \text{gas} \]

a. Heat is involved because it increases the kinetic energy of the molecules which leads towards a phase change. This is shown by the increase in temperature, which is a measure of average kinetic energy. The slope is not constant because in order to go from solid to liquid and liquid to gas, heat is absorbed and water breaks bonds to free up the molecules, which is why the temperature plateaus during a phase change. These phase changes occur because the particles are moving faster when they have more KE and are colliding with each other and their container more frequently, causing a decrease in density, which represents molecules spreading out.
b. The second curve of a substance that is not as cohesive as water has lower boiling points and melting points than H$_2$O. This is because it takes less kinetic energy for those particles to break free from one another and enter the next phase. This is depicted by the lower plateau on the graph. Also, the second substance would likely have a shorter plateau, because the intermolecular bonds are weaker, so it would take less energy to break them apart to enter the next phase. This is why the plateau to draw on the graph because some labels were in the text, but it is depicted by the shorter distance traveled on the x-axis when the slope is relatively flat.

C. 21% +

Temperature (°C)

0°C

Phase (Sublimation) → Gas

Heat added

The heating curve depicts dry ice, which at atmospheric pressure, sublimes from solid goes through sublimation (solid → gas) around room temperature. This is shown by the plateau just above 0°C although it may occur lower than that, I just know it definitely happens at room temperature. As with water, the plateau occurs because it requires energy to break apart the bonds between molecules in the solid phase, so that they are able to move freely in the gas phase. If the pressure were different, the curve would depict all three phases but this is not the case.
2. The famous “tilting bird” is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It’s not enough to say, “do this and it works.” You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot “do” anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation:

A.) The birds that are not tilting are not tilting because there is no force of pressure inside of them. The liquids within them are not sufficient to overcome the outward force of gravity.

I believe the birds that are tilting are tilting because there is more pressure in there than the atmosphere creating a pressure effect. When the bird is tilted a little bit, it allows the liquid to climb, because the force of gravity is not acting in direct opposition to its upward motion. At that point, the pressure difference is enough to push the liquid up a ways up the tube. The point point is continues located above in a place where as more liquid moves up, it begins to tilt more and more. This process occurs until the tube fills, with so much liquid that it tips over the bird enough so that the bottom of the tube is exposed to the air bubble in the bulb at the bottom, at some air is less dense than the liquid, and rises, forcing the liquid up and out of the inner tube along the sides of the glass and fills the bulb up again, returning it to the upright position. But, since there is less pressure on the inside, the process occurs over again as the bird is still resting from its rest. The most important factors are the point point, the shape of the tube, and the pressure difference.
A way to test two hypotheses would be simply to poke a small hole in the glass tube, and see if it still behaves the same. Another way would be to put the tube in an environment where the pressure is less. If you use a drill to make a small hole and cause it quickly for the gas to escape some distance from the tube, which would indicate a pressure difference, you may observe air coming out of the tube which would indicate a pressure difference.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call "the weather". In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

The air in the clouds and the behavior of the clouds is affected by pressure, temperature, and the amount of water in the air. With little pressure (barometric pressure), the water can stay in the gas phase/liquid phase easily because there is less of a force pressing molecules together. But, an increase in pressure will force molecules together causing them to condense into liquid and actually fall as rain. If the temperature is increased, the air in the clouds is hotter and the cloud has more energy and thus is therefore less dense and lighter in a sense. With a decrease in temperature, there is less energy, it is more dense, and tends to condense and fall as rain. Also, the number of molecules that are in a given cloud, the more likely they are to collide, condense, and fall.

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you were talking about. Most metals and liquids expand with a temperature increase because an increase in temperature indicates an increase in the average kinetic energy of the substance, meaning the particles are moving faster. With faster movement, the particles will be more likely to collide with one another and bounce faster apart, eventually resulting in all the particles spreading out, which is recorded by the expansion of the substance overall. There is still the same number of molecules, but the volume increases which means the substance is less dense, which is another way to say that it has expanded. It doesn’t spread out of control because intermolecular attractions keep the substance together while their movement spreads them apart. An increase in movement begins to overpower the attracting, resulting in expansion.
5. Some plastic kitchenware is "dishwasher safe" and some is not. It's not about whether the stuff will dissolve, it's about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

Each end and corner represents a C atom. For example, is

\[ \begin{align*}
&\text{H} \\
&\text{H} \\
&\text{H} \\
&\text{H - C - C - C - H} \\
&\text{H} \\
&\text{H}
\end{align*} \]

Type A looks like this:

Type B looks like this:

Type A is more likely to be dishwasher safe because its solid form will have a more uniform, densely packed structure since it doesn't have the branches like Type B. This will make each molecule closer together, and therefore a more rigid structure because the attractions are closer, and this will give it a higher melting point than B, because it will take more energy and movement to break these bonds.

6. Ammonia is the substance NH₃.

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.

<table>
<thead>
<tr>
<th>Solid</th>
<th>Liquid</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Solid" /></td>
<td><img src="image2.png" alt="Liquid" /></td>
<td><img src="image3.png" alt="Gas" /></td>
</tr>
</tbody>
</table>
Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

   Reason for choice: **Absolute Zero is a measure of 0 kinetic energy of particles**, and although it is only theoretical, it must be the same everywhere because it describes a condition of no particular motion, which can only happen at one point regardless of gravity, pressure, etc.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

   Reason for choice: **This way, the substance will stay in the liquid phase for a wider range of temperatures**, which will allow the thermometer to show changes in density of the liquid for all temperatures at which it is a liquid. Basically, a low melting point and high boiling point give you the widest range of temperatures at which it works.

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

   Reason for choice:
   
   This was easier with the real-time understanding mechanism although the temperature of the substance was room temp. Also, the potential for the chemicals in things like hot sauce and hot peppers, which give a burning sensation (which reveals neurons being triggered) although the pepper is not actually warm.
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

Reason for choice: These ions are charged particles which create a charge difference along the cell, and this difference is what an action potential involves, and the signal itself is the change of these charge differences.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don’t have to provide an answer to that question.

   A can with a small amount of water is placed over a hot stove until steam comes from the can, then it is quickly flipped upside down and placed in a tub of cold water, and is crushed. Why does this occur?

   This is a good question because it relates pressure, temperature, and volume as well as phase change. It requires the student to walk through a multi-step process and explain how each step leads to the final result. This is a critical thinking question similar to the titling birds and involves all the concepts we’ve studied.
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

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   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.
   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

![Ideal Heating Curve for Water](image)

a) The ideal heating graph for water is illustrated to the left. At the start, the water is at -40°C, which is below the freezing point, meaning that the water is in its solid state, ice. As the water is warmed, heat from the source (or surroundings, if in room temperature) will transfer from the source to the ice because the source is at a higher temperature. The initial warming will go quickly because the difference between the temperatures is so significant. At 0°C, the water turns to a liquid. It remains at 0°C for some time because the bonds need to be broken in order for the phase to change.

b) With this new substance, that is equivalent in mass to water, but whose molecules are less attracted, the ideal heating curve takes the same shape as the water curve. The phases still change, but it occurs much faster than water because the bonds are easier to break which means that less heat, or energy, is required for phases to change.
After the bonds are broken and the phase changes, the liquid will slowly warm to 100°C. At this point, the boiling threshold must be broken. The heat energy gained from the source help the molecules speed up and break free. The now water vapor will continue to take in heat slowly until it reaches 140°C.

The heating curve for dry ice resembles the curve of water and other substances, but there is one major difference; the graph only levels off one time, as opposed to two, which corresponds with phase change. When dry ice is heated, it does not melt to form a liquid; instead, vaporizes and turns into a gas.
2. The famous "tilting bird" is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It's not enough to say, "do this and it works". You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot "do" anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

One tilting bird sways slightly from front to back, but always remains upright. The other tilting bird tilts down to a 90\(^\circ\) angle, running parallel to the floor. The bird that tilts constantly collects the liquid in the pipe that holds the bird's head, while the other bird does not. As the pipe fills up, the bird tilts to a 90\(^\circ\) angle. Once in this position, the liquid runs back and forth, eventually letting all of the liquid empty out, thus turning him upright again. To think that the bottom of the pipe is closed off in the upright bird, and open in the tilting bird.

To test this, I would fill up the birds with a different substance and observe the effects. If the results were different, I would know my hypothesis was incorrect and I would have to do more observing of the tilting birds.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call "the weather". In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.

As temperature rises, heat is being added to the environment. Heat is the transfer of energy from a warmer object to a cooler one. As the temperature rises, the heat from the environment is entering the metal or liquid because the substances are cooler. As energy, in the form of heat, is added to the metal or liquid, the molecules are gaining kinetic energy. When energy is added to the molecules, they speed up their motion and they spread apart from one another. As the molecules spread apart to take up more space, the metal or liquid expands.
5. Some plastic kitchenware is "dishwasher safe" and some is not. It's not about whether the stuff will dissolve, it's about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

Each end and corner represents a C atom. For example, \( \text{H H H} \)

\( \text{H-C-C-C-H} \)

\( \text{H H H} \)

Type A looks like this:

Type B looks like this:

I think Type A is dishwasher safe because it has a more rigid structure, which means the bonds and attractions between the molecules are stronger, thus requiring more heat to break. Once enough heat is added, bonds will break and the phase will change to liquid, thus melting. Strong bonds are harder to break and have a higher melting point and can be

6. Ammonia is the substance \( \text{NH}_3 \) put into the dishwasher.

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.
Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

   Reason for choice:
   Absolute zero is the coldest temperature and I would anticipate it would be the case on every planet. We cannot reach absolute zero, but we can get very, very close.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

   Reason for choice:
   The substance inside of the thermometer would need to remain a liquid for the longest period of time in order to rise and fall to accurately determine the temperature, which is why I chose a low melting point and a high boiling point.

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

   Reason for choice:
   When answering this, I think back to the posters we made with the man going into the hot tub and then the cold lake. As he was transferring between the two, he did not experience a cold sensation because it was such a short exposure. He experienced sensation in the tub and lake because he was submerged for a longer period of time.
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a buildup of thermal energy inside the nerve cell

Reason for choice:
I remember action potentials having to do with sending sensation messages to other parts of the body. Once thermal energy is built up, the message is sent.

11. Perhaps you were prepared to respond to a question I did not ask.

Write down that question, and explain why that would be a good question. You don't have to provide an answer to that question.

Explain why and how frost exists.

This would be a good question because frost does not involve all three phases. It only involves two. Heat is required to change phases, but it is not an ordinary substance.
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]
   a. Sketch an “ideal” heating curve for the substance H₂O if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.
   
   Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.
   
   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

   \[ \text{At } -40°C, \text{ H}_2\text{O is in the solid form, and as heat is applied, temperature increases. This means an increase in kinetic energy. At } 0°C \text{, the graph flattens because the kinetic energy is utilized towards phase change, and not temp. increase. Once in liquid form, temp increases as molecules move faster and rotate more than they did in a solid phase. At } 100°C \text{, the graph flattens again, and once again, the energy is used for phase change rather than temp increase. This is the boiling point, where water changes from a liquid to a gas. At } 140°C \text{, the H}_2\text{O is in a gas form.} \]
Since the molecules of this substance are not as attracted to each other as water, they require less energy to change states. That is why the melting and boiling points are at a much lower temp.

* When enough heat is added to dry ice, it does not phase change from a solid to a liquid, but from a solid to a gas.
2. The famous "tilting bird" is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It's not enough to say, "do this and it works". You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot "do" anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

a) An explanation for the famous "tilting bird" - In the bottom glass ball of the bird, there is a red substance, shown as the shaded region in Figure A (shown to the left). Due to some fluctuating pressure exerting the small glass ball, the temperature of the substance changes, because there is a fixed volume.

A law states that at a fixed volume, pressure and temperature are directly proportional. As pressure increases, the substance is shot up the tube leading up to the bird's head. Since there is an increase in pressure, there is an increase in temperature, which yields an increase in kinetic energy. Since kinetic energy is the energy of movement, we see the bird move constantly.

b) An experiment could be done to test the explanation:

i) Apply pressure to a variety of liquid substances and see how the temperature changes. Some sort of thermometer would be needed.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call “the weather”. In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

When the temperature of the atmosphere rises, water on the earth’s surface begins to evaporate (turn from a liquid to a gas) and travels upward. At a certain point of elevation, the temperature is no longer at a point that yields the evaporation process, so a collection of water droplets stay suspended, forming clouds. When the sun is strong or there is a high temperature, clouds evaporate. This is why clouds are sparsely seen on hot days.

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you were talking about.

If a vacuum sealed aluminum (metal) soda can is placed in a fire, after a certain temperature and exposure to the high heat, the soda can will make a loud "POP" noise. This indicates that the liquid expanded inside the aluminum can due to the heat, which made an increase of pressure in the can, which eventually made it "blow up." Born the metal and the liquid expand because the high heat makes the molecules move at a faster rate and move closer to their melting/bubbling points.
5. Some plastic kitchenware is "dishwasher safe" and some is not. It's not about whether the stuff will dissolve, it's about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

Each end and corner represents a C atom. For example, \[ H \ H \ H \]

\[ \ H - C - C - C - H \]

\[ \ H \ H \ H \]

Type A looks like this:

Type B looks like this:

In the solid form, molecules are in an orderly, geometrically consistent shape, where the molecules only slightly vibrate. Since Type A molecules display a more uniform structure, they would "pack together" with other Type A molecules in a much more condensed form than Type B molecules. Therefore, a higher temperature would be needed to separate the molecules (which is what happens during melting).

6. Ammonia is the substance \( \text{NH}_3 \). Type A = dishwasher safe

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.

Solid

Liquid

Gas
Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

   Reason for choice:

   *Nothing can possibly be colder than absolute zero, so it would be the same on all planets.*

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

   Reason for choice:

   *This would provide the widest temp. range for a liquid to stay at the liquid form.*

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

   Reason for choice:

   *Examples - menthol and hot sauce*

   *Certain chemical substances can bind to cold/heat receptors, leading to the sensation of "cold" or "hot"*
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

   Reason for choice:
   Thermoreceptors are in the cells which detect heat / cold, which detect thermal energy.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don’t have to provide an answer to that question.

   Why does sweating cool a person
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]
   a. Sketch an "ideal" heating curve for the substance H_2O if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.
   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water's. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.
   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

b. Because of lower affinity for self, this substance is easier to separate from other molecules of itself to induce phase change.

c. Transition from solid directly to gas (sublimation)
2. The famous “tilting bird” is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It’s not enough to say, “do this and it works”. You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot “do” anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

The pressure in the bird is sealed like a vacuum. As the bird tips back and forth, liquid is pushed up the center tube by the motion.

When the liquid reaches the top and spills out into the head container, it starts to get top heavy and tips over. While on its side, liquid is allowed to spill back from the center tube into the bottom vessel so it stands upright again and the whole process starts over again.

This could be tested by first removing the decoration from the top of the bird so that what is happening in the bird can be observed.

We could test the way in which the bird works by varying the amount of liquid contained in it. There needs to be enough liquid so that when tipped sideways, liquid can spill down into the center tube and thus “vacuum sealed” there when tipped back up.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call "the weather". In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

When air molecules condense to form clouds, water droplets that have been cooled by the surrounding air collect at the base of the cloud. If the cloud becomes dense enough, the droplets will fall and produce rain. Lighter, less dense clouds are found higher up in the atmosphere.

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.

As the metals and liquids are heated, thermal energy is converted into kinetic energy and is incorporated into the molecules. This causes them to vibrate more, makes them less organized, and causes more space between the molecules. This added space causes them to expand. Also, according to Boyle's law, as temperature increases in a system, so does its volume, so long as pressure and mass remain constant.
5. Some plastic kitchenware is "dishwasher safe" and some is not. It's not about whether the stuff will dissolve, it's about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

Each end and corner represents a C atom. For example, \[
\begin{array}{c}
\text{H} \\
\downarrow \\
\text{H - C - C - C - H} \\
\downarrow \\
\text{H} \\
\end{array}
\]

Type A looks like this:

Type B looks like this:

Type A is more dishwasher safe because when you have multiple molecules, they will pack together real tight and be hard to separate and melt (lower mp). All of the kinks in the unsaturated Type B makes it easier to melt because they can't pack so close together.

6. Ammonia is the substance \( \text{NH}_3 \).

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and then turned into the gaseous form. No verbal explanations.

Solid                  Liquid                  Gas
Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

Reason for choice:
Though temperatures on different planets might vary due to atmospheric conditions, the ratio of how different substances take in energy is constant. It will always take less energy to melt mercury than it would for ice, regardless of specific temperatures.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

Reason for choice:
I would want the substance to remain a liquid even at very low and very high temperatures.

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

Reason for choice:
Stronger sensations do not mean the neurons fired stronger action potentials. It just means the pattern and frequency at which action potentials fired was stronger.
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

   Reason for choice:
   During action potential, sodium ions rush into the cell, raising the voltage of the inside to a positive threshold, and then sodium-potassium pumps balance the voltage difference back out. Voltage differences in one area triggers the movement of ions farther down the membrane.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don't have to provide an answer to that question.

   I thought there would be a question regarding the contributions of different scientists historically. Though I'm not sure if I'd be in answering it, it would have related back to the history readings we did.
1. You conducted experiments with heating and cooling curves. [20 pts]
   
   a. Sketch an "ideal" heating curve for the substance H₂O if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.
   
   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water's. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.
   
   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

2. As heat is added over time, the temperature of H₂O increases. At the phase changes (melting point - 0°C; boiling point - 100°C), the temperature of H₂O does not rise. The heat energy is being used toward the phase change rather than to increase the heat/kinetic energy/movement of the H₂O molecules. The heat is used for potential energy.

3. The other substance is represented in pencil. The substance, we'll call 'X', is the same mass, so the kinetic energy is the same as H₂O. The molecules are moving at the same speed within each phase. Because X is less attracted to each other than H₂O, it takes less potential energy to change phases, and move the X molecules apart. Therefore, X can start using kinetic energy to increase temperature faster. Substance X will also have a lower melting point + boiling point for this reason.
Dry ice, or solid CO₂, does not go through the liquid phase. When heat is added, the molecules use the energy as kinetic energy and increase movement within the solid phase, until a certain temperature. At this temperature, the molecules use the heat energy for potential energy to break apart and float freely in the gas phase. This is called sublimation.
2. The famous "tilting bird" is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It's not enough to say, "do this and it works". You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot "do" anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

a. I'm not sure what the liquid in the bulb have to do with the bird. However, I have discovered that the bird tilts more when I use more force. When I stop it and gently tap it, it doesn't tilt much. When I use more force, it tilts much more. As time passes, the bird levels out and tilts much less. I believe this could be because the head and the bottom are possible equal in weight. The bird with liquid in the neck does not go to equilibrium. I would think the liquid throws off the weight balance between the head and the bottom bulb.

b. To investigate this, I would need to measure the weight of the bottom (w/liquid in just the bottom) and the weight of the top separately. If they are equal, I believe my hypothesis is correct. This phenomena probably can be explained with one of Newton's laws.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call “the weather”. In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

As the air mass cools off, the molecules change from gas to liquid. The molecules lose kinetic energy and move less, which is why they form clouds. As clouds, the molecules are not as free-moving as they were as gas, but they are still spinning and colliding. They are closer together in the liquid phase, but they are not as tightly packed as they would be in the solid phase.

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.

The fact that metals and liquids expand when heat is added is consistent with the molecular level. For example, in the solid phase, molecules are tightly packed, vibrate, and overall have very little movement. However, as you begin to add heat, the molecules use the heat as kinetic energy and begin to move more. Eventually, they move enough where they start to separate a bit. The same is true for liquids. As heat is added, molecules move more and spread apart.
5. Some plastic kitchenware is “dishwasher safe” and some is not. It’s not about whether the stuff will dissolve, it’s about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

| Each end and corner represents a C atom. For example,                               |
| H | H | H |
|   |   |   |
| H-C-C-C-H |
|   |   |   |
| H | H | H |

Type A looks like this:

Type B looks like this:

I believe Type A is not dishwasher safe. Type B can be put in the dishwasher because it would be more difficult to melt. The “kinks” in the carbon chains make it difficult for the molecules to break apart and melt into liquid. As a solid, both types have molecules that are tightly packed. Type B’s molecules are packed in a specific, complex way because of the kinks. Type A are simply laid one on top of the other.

6. Ammonia is the substance NH₃ which takes less energy to break apart.

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.

Solid

Liquid

Gas
Multiple Choice plus Explain [5 pts each]

7. If we ever found a humanoid civilization on another planet (with the same level of
technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

   Reason for choice:
   The exact numbers of the melting points of ice and mercury would not
   necessarily be the same on another planet because of difference in mass, atmosphere,
   and other factors. However, I would think it would take about the same
   amount of heat energy to break apart the molecules, relative to absolute zero, and change phases.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

   Reason for choice:
   You would want to use a substance that will stay a
   liquid for the greatest range of temperatures, this
   way it will not freeze when measuring a very low
   temperature or boil when measuring a high temperature.
   Therefore, the melting point should be low enough where it won't
   freeze and the boiling point should be high enough where it won't boil.

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

   Reason for choice:
   We discussed that there were two different
   thermo receptors. The ones that responded to heat
   could be found all over the skin. The ones
   that responded to cold could be found on the
   skin and tongue.
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

   Reason for choice:
   An action potential in a nerve cell is fired across an axon when there is an influx of sodium ions and an outflow of potassium ions.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don’t have to provide an answer to that question.
   
   What is evaporative cooling?

   This would have been a good question because we discussed this in class after reading the articles on ice making in the East Indies and how the porous bowls acted like our skin when we sweat.

   Another good question to have asked would be about the relationships between temperature, pressure, and volume because we spent a lot of time on that with graphs and the PhET simulation.
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]
   
   a. Sketch an “ideal” heating curve for the substance H₂O if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.
   
   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.
   
   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

   ![Graph of Heating Curves]

   As heat is added to H₂O when it is in the solid form (ice) the molecules keep moving faster until the ice lifts its melting point and then even though there is heat still being added the temperature stays the same while it changes to a liquid. Then the temperature of the liquid keeps rising and the molecules move even faster until it hits the boiling point and then the liquid turns into a gas. These phase changes are caused by broken bonds between molecules.

   b. The difference between water and the other substance is that it doesn’t take as much heat to break the bonds in the other substance. Therefore the melting and boiling points are lower than water’s and the phase changes can happen at lower temperatures.

   ![Graph of Dry Ice Heating Curve]

   Dry ice doesn’t change from a solid to a liquid. Instead it has a sublimation point when the solid changes from a solid straight to a gas. This happens right around room temperature and all the way until that point it stays a solid.
2. The famous "tilting bird" is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and turn over and over. Your explanation must be mechanistic. It's not enough to say, "do this and it works." You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot "do" anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

As one of the tilting birds tilts over and over again the liquid rises up the tube until it hits the top and then as the bird tilts back over it causes the liquid to go back down. However the other bird doesn't raise the water and, in fact, doesn't tilt at all. This leads me to believe that the reason the one bird tilts was to do with pressure. When we did the experiments with the closed syringes we saw that if there was a defined pressure and volume if you tried to move the top of the syringe up it was "pulled" back down. I think that the space in the tube has had all of the air or gas sucked out. This leaves the entire volume of the tube to be filled by the liquid. The molecules in water want to move around to fill its given space. Since the volume is defined the liquid moves to fill some of the extra space. However he liquid's volume is also defined so at a certain point (the "flipping" point) the bird then moves to fill the new space at the bottom. A way to experiment this idea would be to allow air (gas) to fill up some of the space inside the tube. This is somewhat like our experiment with dry ice as the gas from the sublimation process caused the syringe up to move up. The pressure increase so the volume, had to increase. In his experiment the volume is unable to increase but the pressure is all there, so this causes the water to keep moving.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call “the weather”. In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

As the water rises to form water droplets in a process called condensation, the molecules in the water are now starting to stick more together (just like in the PhET simulations). This causes us to see the clouds that we see in the sky. This is why the clouds shape change so easily but still hold a somewhat defined shape because water vapor is very similar to water on a table. As this condensation process happens, heat is given off into the air. The allows the rest of the air to stay slightly warmer and therefore in a gaseous form. It is almost the opposite of the evaporation-cooling effect we talked about.

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you were talking about.

As metals and liquids heat up, their molecules move faster. If the substance they are part of doesn’t have a definite shape or is malleable, the rapid movements of the molecules will cause more collisions which in turn will cause the pressure to build. If the volume isn’t absolutely definite, an increase of pressure causes an increase of volume which would cause both the liquid and metals to expand.
5. Some plastic kitchenware is "dishwasher safe" and some is not. It's not about whether the stuff will dissolve, it's about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

Each end and corner represents a C atom. For example, is

\[ \overset{\text{hydrogen bonds}}{\text{H - C - C - C - H}} \]

Type A looks like this:

Type B looks like this:

I think type A would be dishwasher safe. I believe that the uniform consistent structure and the hydrogen bonds (between all the molecules) would require more heat to break the molecules’ bonds apart. Therefore it would take more heat at a higher temperature to melt the plastic.

6. Ammonia is the substance NH₃

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.
Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

   Reason for choice:

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

   Reason for choice:
   This way the liquid wouldn't turn into a solid unless it got really cold and it would boil and turn into a gas until it got really hot. Either of these would cause it to be impossible to read the temperature.

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

   Reason for choice:
   We also talked about how chemicals in hot peppers cause the body to have a reaction like it is very hot, and how chemicals in gum cause the body to have a reaction like it is cold.
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

   Reason for choice:
   This is the way that messages are communicated from the brain down to a specific part of the body by neurons firing an electric signal.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don’t have to provide an answer to that question.
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]

   a. Sketch an “ideal” heating curve for the substance H₂O if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.

   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.

   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

   

   As heat is added and the temperature of H₂O increases, the molecules are gaining kinetic energy and moving more quickly. At the melting point, the temperature increases more slowly because the energy is going into disrupting the attraction between molecules instead of increasing their speed. As the attraction between molecules decreases, the H₂O changes from solid to liquid, and the temperature begins to rise steadily until the boiling point. Here, the same thing occurs, except the H₂O is changing from a liquid to a gas. This is possible because the molecules are not as attracted to each other, so they are able to spread apart and act more independently.

A substance that is the same mass as water but not as attracted to other molecules would be easier to break apart. Less energy would be needed to cause a phase change, so they would occur at lower temperatures than water.
Dry ice sublimes from a solid to a gas. I'm not sure at which temperature this actually occurs, but it is colder than room temperature. Since there is no transition to liquid phase, there is only one plateau. This shows where the molecules are gaining enough energy to break free of the solid mass and become a gas.
2. The famous “tilting bird” is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It's not enough to say, “do this and it works”. You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot “do” anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

In the bird that tilts, the liquid is being drawn up the tube from the bulb. When it gets to the top, the vial swings forward, the liquid runs back down, and the vial tips back and starts the process again. In the other bird, the water is not drawn up the tube and it stops swinging. A possible explanation for this is the molecules of the liquid in the tilting bird are more attracted to each other than the molecules of the liquid in the non-functioning bird.

The attraction between molecules allows them to be pulled up the tube. When the liquid reaches the top, the increased weight tips the bird horizontal, causing the liquid to drain back down and increase the weight on the other side. This cannot happen in the other bird because the molecules are not as attracted to each other or the sides of the tube, so will not be drawn up into the tube.

A way to test this would be to empty out the birds and put known substances in them. If the previously non-functioning bird could be made to work by putting a liquid known to be more attracted to other molecules, and the functioning bird could be made to not work by doing the opposite, it would show that the birds’ behavior is due to the liquid inside and not a mechanical character's difference between the birds.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call “the weather”. In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

As the water droplets form, the must give up heat to their surroundings. This is because they are giving up kinetic energy in the form of thermal energy in order to slow down. The warmth released from the formation of new droplets would increase the temperature of the surrounding droplets forming the cloud. This prevents the cloud from turning into a ball of water in the sky and falling down.

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.

These substances expand when heated because the molecules are spreading apart. As heat is added, the molecules gain kinetic energy and are able to move around more. The attractive forces between molecules are also weakened as energy is added, so the molecules are able to move away from each other. This results in the overall volume of the substance expanding.
5. Some plastic kitchenware is “dishwasher safe” and some is not. It's not about whether the stuff will dissolve, it's about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

Each end and corner represents a C atom. For example, is

\[
\begin{array}{c}
  \\
  \\
  \text{H - C - C - C - H} \\
  \\
  \text{H} \\
\end{array}
\]

Type A looks like this:

Type B looks like this:

Type A is dishwasher safe. It is less likely to melt when exposed to the heat of the drying cycle because it is symmetrical. These molecules will fit tightly together, so they will be harder to separate from one another and cause a phase change. Type B molecules will not fit closely together, so they will be easier to separate from one another. It is more likely Type B will melt at the temperatures produced in the dishwasher.

6. Ammonia is the substance NH₃. Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.

Solid  

<table>
<thead>
<tr>
<th>Solid</th>
<th>Liquid</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Solid" /></td>
<td><img src="image2" alt="Liquid" /></td>
<td><img src="image3" alt="Gas" /></td>
</tr>
</tbody>
</table>
Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

   Reason for choice:
   [Reasonary Earth]
   Atmospheric pressure will be different on the other planet. Pressure affects phase change. Decreased pressure will allow substances to melt at a lower temperature, but increased pressure will require a higher temperature. However, because the molecules are still the same, we can expect that their melting points will be the same proportionally.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

   Reason for choice:
   A low melting point means the liquid in the thermometer will not freeze until it is very cold. Hopefully, so cold that it will not occur at that climate. A high boiling point means the substance will remain liquid until it is very hot. This keeps the thermometer functioning over a wider range of temperatures than if it were to become solid and unable to move or read and stop expanding, at mild or common temperatures.

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

   Reason for choice:
   We talked about capsaicin, which triggers a sensation of heat even though it is not hot in temperature. This happens because the chemical happens to be able to bond to the thermoreceptors, which activates them. The pathway is the same as would occur with a temperature stimulus, and the sensation of heat is perceived by the hypothalamus. Other chemicals can cause a cold sensation even though the tissue is not actually losing heat. This phenomenon can even lead to systemic response to the perceived change in temperature, such as sweating and dilation to give off heat, even though there is no physiological need.
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

   Reason for choice:
   Action potentials form when electrolytes carrying different charges move from inside the cell to outside or vice versa. This leads to a charge on charge across the cell membrane, which travels along the axon of the neuron. The message is passed on the the next cell across the synapse in the form of a neurotransmitter, and the same process of exchange of ions and development of a charge across the membrane repeats until the message reaches its destination.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don't have to provide an answer to that question.

   I was prepared to answer a question about the nature of heat, such as describing whether heat is a separate phenomenon from cold. It is a basic concept, but an important one because in order to understand the other concepts we have explored, we must understand that heat is an indicator of the amount of energy in a substance and cold reflects a loss of energy.
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]

   a. Sketch an "ideal" heating curve for the substance H$_2$O if you start with the substance at a temperature of ~40°C and end at 140°C. Label the axes. Identify the features of the graph. Describe how heat is involved.

   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water's. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.

   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

   As heat is added the molecules gain more energy. They move faster. At a certain point the energy is being used to break bonds. This is when a phase change occurs and is represented by the plateau. The temperature does not increase because the energy is being put to another use (breaking attractive forces). Once these bonds are broken, the heat is used to increase the kinetic energy of the system and the temperature increases.

   For the substance in part B, the melting and boiling points occur at lower temperatures. This is because less energy (in the form of heat) is needed to break the attractive forces (bonds) between the molecules. This occurs because the molecules are less attracted to each other. The forces are weaker.
2. The famous "tilting bird" is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It's not enough to say, "do this and it works". You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot "do" anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

**Observations**

- Fluid in the bowl (bottom) of the bird. A stem goes down into the bowl and is open. The liquid moves up and down this stem.
- When liquid reaches the top of the stem, the bird moves back and forth a few times and then tilts all the way forward. The tube empties, the bird hips back, and the process begins again.
- The other bird at the table is not working this way. Fluid does not move up the stem. On this one the stem goes all the way down to the bottom of the bowl.

**Thoughts**

I believe that the tilting has to do with pressure. The liquid moves up the stem because it is moving in the direction of less pressure. In addition, the molecules of the liquid are more attracted to each other than to those that make up the tube. This allows them to not stick to the container and move up it. This movement of fluid up the tube changes the weight distribution and causes tilting. When the tube is full of fluid the weight distribution causes it to tilt all the way forward. The end of the tube is no longer submerged and less pressure exists in the bowl. The fluid then moves back to the bowl and the process begins again.

**Experiment**

I would like to try the same set-up but with a larger diameter tube (the stem remains the same). I believe this would make for a more equal pressure gradient (or no gradient) be attracted to each other but the pressure gradient would be minimal. The molecules of the liquid would still only move up the tube. A smaller diameter tube would not "fit" in to changes.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call "the weather". In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

Clouds are formed because as the temperature decreases, the water molecules slow down and come closer together. A phase change occurs. The water molecules are in the atmosphere, but air is between them. As more water evaporates and condenses, the ratio of water to air changes (more water droplets). In addition, when the water condenses, heat is being given off because bonds are being formed. The energy that the molecules harnessed to separate and become a gas is no longer being used and is released. I assume this released energy is used in other weather processes. At a certain point the cloud becomes so concentrated with water that it rains. Enough water molecules come together that they can no longer resist gravity and it rains.

Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.

An increase in temperature adds heat to the metal or liquid in question. This heat is a form of energy. When the atoms/molecules in a solid or liquid are heated, the increase in energy provides for more energy. The molecules then are able to move faster. In addition, the increase in energy allows them to at least partially overcome the bonds between them (partially meaning not all bonds between molecules are broken until a complete phase change occurs). The breaking of bonds and increase in energy causes the molecules to take up more space and the metal or liquid subsequently appears to have expanded.
5. Some plastic kitchenware is “dishwasher safe” and some is not. It’s not about whether the stuff will dissolve, it’s about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

<table>
<thead>
<tr>
<th>Each end and corner represents a C atom. For example,</th>
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<td>H</td>
<td>H</td>
<td>H</td>
</tr>
</tbody>
</table>

Type A looks like this:

Type B looks like this:

Type A would be dishwasher safe while type B is not. Type A has a very uniform structure that “packs” together well. Type B contains many “kinks” that make it harder to pack together. This means that less energy (heat) will be needed to break the bonds between molecules in type B. Hence, the melting point for Type B will be lower than type A and it will be more likely to melt in the dishwasher.

6. Ammonia is the substance NH₃

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.
Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

Reason for choice:

The temperature at which a substance melts depends on the atmosphere's pressure. I believe for this reason, the temperature of absolute zero would also be affected. However, the ratio of melting points for H₂O and Hg would still be the same in relation to absolute zero because the "stickiness" of their bonds remains the same.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

Reason for choice:

Using a substance with a low melting point and high boiling point for reference would be useful because very "cold" and very "hot" temperatures would be the reference points. They could essentially serve as the two poles or extremes for the temperature scale.

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

Reason for choice:

We discussed that intense heat or cold is differentiated from mild heat or cold by how rapid the action potentials are being fired. This tells your body how quickly and how to appropriately respond (more heat, etc.). If you consciously override this response and the stimulus remains, the action potentials would
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   X a build up of thermal energy inside the nerve cell

   Reason for choice:

   An action potential involves ions (particularly sodium and potassium) entering and exiting the cell. This creates a charge that is sent down the axon and triggers the next cell (more movement of ions). This movement is only temporary and creates just one action potential.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don't have to provide an answer to that question.

   I expected there to be a question about evaporative cooling. (Maybe there was and I did not catch this.) An example of a question would be to ask why we become cold when we are wet (even if the water is equal to our body temperature). We are not cold while we are submerged in the water, but are cold when we get out.
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]
   a. Sketch an “ideal” heating curve for the substance H₂O if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.
   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.
   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

   ![Graph of heating curve]

   As time goes on, the temperature rises as heat is added. In the situation the water begins as a solid and undergoes phase change, passing through the melting point (0°C) and the boiling point (100°C). The heat being added weakens the bonds between the water molecules. As the molecules break free from the structure, the heat forces them to move around and collide with one another (kinetic energy).

   b) The curve for the unknown substance would be much steeper because it would take less time for heat to weaken the attraction between the molecules. The substance would undergo phase change more rapidly.

   ![Graph of dry ice heating curve]

   The dry ice is heated from a solid state to a gaseous state. The gas phase occurs at room temperature (20°C), meaning when we see dry ice in the classroom, we are viewing it as a gas, not a solid like the name would imply. To be seen as a solid, gas dry ice would have to be viewed in some very cold setting.
The famous "tilting bird" is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It's not enough to say, "do this and it works". You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot "do" anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

The birds are tilting because of the amount of energy among the molecules of the substance which is forcing the substance upward to the other end of the scale. The bird has to be moved first to maintain a constant motion. This demonstrates how molecules in a contained, constant temperature container interact with one another.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call “the weather”. In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

The air in the clouds is the water that didn’t evaporate when the warm air rose. The water in the air took energy from the warm air (heat) and evaporated, making the air mass cooler. The size of the clouds depends on how much water was in the air on that particular day.

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.

As the temperature rises, the heat is weakening the bonds between the molecules by forcing kinetic energy upon them. As this heat fills the spaces between molecules, the molecules become more distant from one another, making the substance expand.
5. Some plastic kitchenware is "dishwasher safe" and some is not. It's not about whether the stuff will dissolve, it's about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

Each end and corner represents a C atom. For example, \( \text{H}_3 \text{H} \)

Type A looks like this:

Type B looks like this:

It all depends on the so-called "stickiness" of a substance. The more organized a structure is (Type A), the easier the molecular bonds are. Type B is dishwasher safe because the molecular bond is stronger and harder to break down with heat.

6. Ammonia is the substance \( \text{NH}_3 \).

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.

Solid

Liquid

Gas
Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

   Reason for choice:
   A, b, and d all depend on outside influences such as attitude and pressure, but the ratio of the melting points of ice and mercury will always stay the same because the substances would be the same here as they would there.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

   Reason for choice:
   A thermometer with a high melting point and a low boiling point would be the most efficient and accurate way to tell the temperature because it is unlikely that the temperature of the air would be as extreme as a high boiling point or low melting point.

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

   Reason for choice:
   There are different neurons that possess more thermo receptors that respond to cold than ones that respond to heat.
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

Reason for choice:

**Action potential is all about the amount of potential energy build up that will then be released into action.**

11. Perhaps you were prepared to respond to a question I did not ask.

Write down that question, and explain why that would be a good question. You don’t have to provide an answer to that question.

*Why does water move toward an object that is positively charged?*
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]
   a. Sketch an “ideal” heating curve for the substance H₂O if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.
   
   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.

   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

   a) When heat is present, it takes the matter through phase changes. The solid H₂O, as it takes in heat, speeds up the molecules. These molecules vibrate and increase the temperature of the H₂O. Then, the temp. stops rising, as the energy is used to break the molecular attraction. This is when the water melts. The molecules are now moving more than before, colliding, and go through the same process in order to evaporate and become a gas.

   b) The basic look of the graph is similar. However, you can see that the phase changes happen at a much quicker rate. In part b, it said that the substance’s molecules are not as strongly attracted as the water’s. This means that they will be more willing to separate from one another and will require less energy to do so.

   The features of the dry ice curve are similar to that of the H₂O curve, yet it takes much longer. Because dry ice is so much colder, it takes a longer time to warm up and go through the phase changes.
2. The famous “tilting bird” is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It’s not enough to say, “do this and it works”. You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot “do” anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

a) The bird tilts because it is interacting with the air pressure. Just like in the reading about the thermometer, when the top was open, the levels of mercury rose because the air pressure was effecting the levels inside, even if the temperature remained constant. So, as the air pressure gets inside the unsealed tilting bird, it causes the liquid to rise. The rocking motion further propels the liquid up, until it becomes too top heavy that it falls down and starts all over again. The resting bird, on the other hand, must have a sealed top that does not become affected by air pressure. Another reason could be the differences in liquid. While the liquid in the resting bird might not be affected by room temperatures, the liquid in the tilting bird might. It will not boil, but it would expand as the molecules bounce around. Just as I explained in problem 4, because liquids expand as temperature rises, it could be more susceptible to room temperature and climb the neck of the bird.

b) I would test the birds by placing them in a vacuum, where air pressure could not affect them. I could also bring the birds to different temperature controlled rooms to see how the liquid reacts.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call "the weather." In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

When the air mass cools off, it rains, because it is getting more dense as it rises. This too can be related to sweat. Your body produces sweat as a means to cool itself off. The sweat can only evaporate, however, when the air is not that dense. Otherwise, the air has too much moisture already (humidity), so the water heads up on you. So, as the air mass rises and becomes more dense, the water in the atmosphere must release itself, like sweat, but falls as droplets because it cannot be evaporated.

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.

Firstly, the liquid, from a molecular level, is concentrated. What I mean by this is that the molecules are all hugging around each other, vibrating, but not as neatly packed as they would be in the solid form. They are able to have a bit of moment and roll over each other. These inter-molecular bonds are not as strong because there is more space between them than there would be in a solid state. When the temperature rises, the heat begins to warm the molecules, and they move around more. This moment causes the expansion, because it isn't until the energy one used to increase the temp, eventually breaks the bonds so a phase change can occur. During this time, the temperature remains constant. This idea can be related to metals as well. The tightly packed molecules warm up, vibrate and move more, and cause the expansion. It would require great amounts of heat to melt the metals. This idea can also be attributed to packry. The more molecules move, the harder it is to contain them neatly, or keep the original shape. This leads to expansion.
5. Some plastic kitchenware is "dishwasher safe" and some is not. It's not about whether the stuff will dissolve, it's about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

<table>
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<th>Each end and corner represents a C atom. For example,</th>
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</table>

Type A looks like this:

Type B looks like this:

Type A will be dishwasher safe because it has a higher melting point. This is because it is able to be stacked neatly. Type B, on the other hand, has some double bonds that make the chain more unorganized. This means it cannot be packed as easily, and will instead be broken apart at a lower temperature. As a result, Type A is safe.

6. Ammonia is the substance NH₃

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.
Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

   Reason for choice: If the absolute zero temperature is the same, then that would likely mean that the other temperatures would be the same. So there would be livable conditions, like warm or cool months, that humans experience, because we also have an absolute zero. Basically, if we have an absolute zero along with habitable temperatures, that planet must be similar.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

   Reason for choice: A low melting point and a high boiling point would ensure the durability and longevity of the liquid. Otherwise, a cold, or hot day could ruin the thermometer. This covers both ends of the spectrum.

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

   Reason for choice: Just like in the ice to sauna example, there are a set of neurons that fire when they feel cold, and another that fire when they feel heat. This enables your body to know what action to take in order to protect itself out of harm. If they respond the same way, you could end up running from one dangerous situation to another.
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

   Reason for choice: increased thermal energy, as has been depicted in the PhET diagrams, causes molecules to move quickly. When thermal energy builds within the nerve cell, it triggers the action potential to fire at an expedited rate.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don't have to provide an answer to that question.
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]
   a. Sketch an “ideal” heating curve for the substance H₂O if you start with the substance at an temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.
   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.
   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

a. How heat is involved: As the temperature rises, more kinetic energy is generated causing the H₂O particles to move more quickly. As molecules' speed increases, they begin to break the bonds holding them together. However, because it takes a good deal of energy to break apart the bonds, it takes longer to change state than to stay in the same state (which can be seen at the stagnant points of the melting and boiling point). The temperature cannot increase dramatically until the bonds have been broken and the state has changed from a solid to liquid or liquid to gas.

b. For a substance whose molecules are less attracted, it would take less time to change state because it would be easier to break apart the molecules' weaker bonds. This is why the dotted line is to the left of water's line, and why there is less of a delay at its melting and boiling points. If molecules are less strongly attracted, less kinetic energy is needed to separate the bonds and change state; so it can change state more quickly.

c. There's no melting point or liquid phase because dry ice vapors straight from a solid to a gas. The time it takes for this vaporization is very short, so the bonds between the molecules must be weak - there must not be very strong attraction.
2. The famous “tilting bird” is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It’s not enough to say, “do this and it works”. You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot “do” anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call "the weather". In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.

When temperature increases, so does the kinetic energy of the molecules in a substance or object. The molecules in a metal or liquid begin vibrating more quickly, causing them to move away from each other slightly (not enough to result in a change of state— in metals, the bonds between molecules would be too strong to change state), giving the appearance of the substances expanding due to the molecules being slightly farther apart.
5. Some plastic kitchenware is "dishwasher safe" and some is not. It's not about whether the stuff will dissolve, it's about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

Each end and corner represents a C atom. For example, \[ \text{H H H} \]
\[ \text{H - C - C - C - H} \]
\[ \text{H H H} \]

Type A looks like this:

Type B looks like this:

6. Ammonia is the substance $\text{NH}_3$.

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.
Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

Reason for choice:
Taking the hypothetical planet's distance from the sun (or its own sun) as well as the size of its sun + other such factors, the melting points of all substances could be completely different from the ones they have on Earth. But absolute zero is independent of these factors, since it is the temperature at which no more thermal energy can be removed from a substance.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

Reason for choice:
You want a liquid that can measure the most extensive range of temperatures possible while still remaining a liquid. If its melting point is especially low + its boiling point is especially high, there is a larger range of temperatures at which it remains in a constant liquid state, + therefore a larger range of temps it can measure. (As illustrated above.)

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

Reason for choice:
Things that "feel colder" (i.e. menthol gum) or hotter (i.e. spices, peppers) contain chemicals that trigger thermosensitive neurons— even though the things themselves may in fact be room temperature. Because both levels of temperature + certain chemicals trigger the same neurons, our brain interprets them + therefore we perceive them in similar ways.
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   c. a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

   Reason for choice:
   I don't remember quite what the details are, but once a threshold has been reached, sodium ions flow into the cell as potassium ions flow out (or vice versa) - this is what the action potential involves.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don't have to provide an answer to that question.
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]
   
   a. Sketch an “ideal” heating curve for the substance H₂O if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.
   
   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.
   
   Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

For water (part a), at -40 °C H₂O would be in a solid state. As temperature is being added the solid form of H₂O, ice, would begin melting. There is a plateau in the graph it is showing a phase change. During a phase change the temperature is not fluctuating, but instead the heat is being used to change the water from ice to a liquid. After the phase change has occurred the temperature will be affected by heat again and begin increasing over time.

For other substance (part b), due to the second substance that has weaker bonds between molecules, the heat will affect the substance much quicker. The amount of heat needed to break the bonds will not be as much because heat will have a greater affect on phase change. As the heat increases, the molecules will tend to break apart more easily and gain more energy quicker because heat will not have to go towards breaking them apart. Unlike water where molecules with stronger polarity need more heat exposure to be affected enough to change phases.
Dry ice is a special substance that skips a phase change due to sublimation. This means that it goes straight from liquid form to a gas and skips becoming a liquid. Due to this, the molecules quickly expand when in an enclosed space because they get from being really close and shaking to buncing around and roaming. The graph shows that it has a positive slope, that as temperature increases time is also increasing and within that there is a phase change. This phase change is much quicker because once the molecules break apart out of the solid phase it goes straight to gas phase which has quicker moving molecules freely moving within the enclosed space. Due to this not as much heat is needed to change solid dry ice to gas form. We had conducted an experiment proving this. Where ever at room temperature sublimation occurred.
2. The famous “tilting bird” is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It’s not enough to say, “do this and it works”. You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot “do” anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

One of the birds, the one continuously moving, uses the total neck to create a continuous flow of liquid. As the bird tilts back and forth, the tube begins to fill with liquid. And once it is completely full, it tilts to a 90° angle with the stand and empties out into the bowl of the bottom. I assume the reason behind it is due to pressure of an air bubble because after watching it empty and refill as it moves, you can watch the air bubble travel down the neck. The other bird does not have is lacking this. It will tilt back and forth a few times, not much isacking thus. It will tilt back and forth a few times, not much is lacking thus. It will tilt back and forth a few times, not much is lacking thus. It will tilt back and forth a few times, not much is lacking thus. It will tilt back and forth a few times, not much is lacking thus. It will tilt back and forth a few times, not much is lacking thus. It will tilt back and forth a few times, not much is lacking thus. It will tilt back and forth a few times, not much is lacking thus.

An experiment that could be performed would be to pressurize the bird that currently does not tilt and see if it performs the same as the bird that already continuously tilts. You could also depressurize the bird that tilts to see if it loses its momentum/energy. To increase pressure, you could add heat to the substance, and to decrease pressure you could cool it. Although true birds are currently in identical environment, you could test true experiment on each one because the substance involved may have a high threshold.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call "the weather". In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected?

The warmer air near the ground we can assume has moisture within it. Since it is less dense and warmer, it rises. As it gains more altitude, it will be interacting with cooler air, which will force it to pass through which will turn the moisture into a more definite form of a small water droplet. These water droplets will cause clouds to form as they pull together due to their attraction to each other. As the air in the clouds and cloud behavior is affected by the amount of water droplets in their formation, pressure within the atmosphere of the current day and overall temperature change as the air rises and sinks. The clouds will have a faster motion in the sky and more dense formation will have a faster motion in the sky and more dense formation will have a greater interval of temperature change. The water droplets will form on the surface of the earth and create clouds that seem close to the surface of the earth.

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you were talking about.

As temperature increases so does the energy within a substance which evidently leads to a phase change when the substance reaches its melting or boiling point. They expand because the pressure of the substance increases and the molecules will increase in speed. Let's assume the metals are in solid form. As the temperature increases the molecules begin moving faster until the eventually begin to break their bonds to one another. But until that point they are letting their bonds, causing the object to slightly expand due to the pressure increasing. The metal will also feel warm to the touch at this point. As for a liquid it tries to expand its surface exposure so that it can gain energy quicker, a change from a liquid to a gas. This is why liquids left boiling on a stove will condense and evaporate through tin steam. 


5. Some plastic kitchenware is "dishwasher safe" and some is not. It's not about whether the stuff will dissolve, it's about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

Each end and corner represents a C atom. For example, \[
\begin{array}{c}
\text{H} \\
| \\
\text{H} \\
| \\
\text{H} \\
\end{array}
\]

Type A looks like this:

Type B looks like this:

I would assume "type A" is dishwasher safe because the molecules have a more definite shape than that of type B so you could assume their bonds are stronger. The structure of type A appears to be less "breakable," so to speak, because it is continuous without any random attachments forming off its original structure. Type B looks almost broken to begin with and fragile if heat was to be added so its bonds would be easier to break.

6. Ammonia is the substance NH₃.

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.

<table>
<thead>
<tr>
<th>Solid</th>
<th>Liquid</th>
<th>Gas</th>
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<tbody>
<tr>
<td><img src="image1.png" alt="Solid" /></td>
<td><img src="image2.png" alt="Liquid" /></td>
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Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
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   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

Reason for choice:
Because unlike water, mercury's melting point is not affected by pressure, and we know that the atmosphere pressure changes in space so water would not be a reliable substance to use because the temps needed to affect it would be different.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   a. a low melting point, and high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

Reason for choice:
I chose this because using extremes in both cases would allow the thermometer to get better use in terms that it would involve intervals of temperature that are not as high or low as the melting and boiling point I would use. This would allow people to get better use out of it and not need multiple thermometers for different scenarios of measuring temperature.

9. When we discussed thermosensitive neurons, we discussed
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

Reason for choice:
The firing of action potentials is caused by exposure to extreme heat or cold. You get a stronger sensation when the action potentials are firing more rapidly. They would be caused to fire more rapidly if they have a higher or lower temp affecting them. In other words, the more extreme the temperature the faster the firing of action potentials and stronger sensation felt by you.
10. An action potential in a nerve cell involves
a. pores in the cell membrane that open and close
b. ions of different types that move from inside the cell to outside, or the reverse
c. a voltage difference across the cell membrane that moves along the membrane
d. a build up of thermal energy inside the nerve cell

Reason for choice:
As the temp increases or decreases the action potentials would be triggered to be released which would occur from then escaping the cell by cell membrane opening and closing. They would open to release the amount needed to trigger a reaction from you to protect what is being affected. They are within the nerve cell and when needed they build up the energy needed to be released.

11. Perhaps you were prepared to respond to a question I did not ask.

Write down that question, and explain why that would be a good question. You don’t have to provide an answer to that question.

I thought you would refer back to how we could connect certain experiments. Maybe for example, how polarity was involved with both the water, oil and balloon and how the bonds can have different strengths. Then connecting this to the PhET simulator or different substances we heated/dropped and what their molecular bonds could have been like. I think this would have been a good question because it relates multiple concepts we have learned and makes us connected through previous observation.
You may respond to these questions in any order. All responses should be legible, in grammatically correct sentences, and have an organized structure. It is better to provide thorough answers than to rush to complete everything. Each problem is 10 points except as noted.

1. You conducted experiments with heating and cooling curves. [20 pts]

   a. Sketch an “ideal” heating curve for the substance H₂O if you start with the substance at a temperature of -40 °C and end at 140 °C. Label the axes. Identify the features of the graph. Describe how heat is involved.

   b. Superimpose on this same graph a heating curve for a substance about the same mass as water, but whose molecules are not attracted to each other as much as water’s. Use the same starting and ending temperatures. Explain any differences between this curve and what you have for water.

   c. Sketch a heating curve for dry ice. Start at some very cold temperature and stop when you get to room temperature. Explain the features of this curve.

   a) As heat is added over time, the water changes phases. The kinetic energy (heat) causes the molecules of water to increase their movement (and speed) and change the phases of water over time.

   b) This heating curve illustrates that the substance heats up faster than water; it takes less time for it to heat up, and change phases. Since the molecules aren’t attracted to each other as much, the bonds (the attraction) will “break” faster than water.

   c) The curve for dry ice does not have the same shape as water because dry ice doesn’t melt; it goes straight from solid to a gas.
2. The famous "tilting bird" is in the room. Some of the birds are tilting, and some are not. Your task is to come up with an explanation for what makes the bird tilt and over and over. Your explanation must be mechanistic. It's not enough to say, "do this and it works". You need to provide a sound scientific explanation that describes HOW and WHY. You can make visual observations and you can touch or move them (gently), but you cannot "do" anything to the bird to test out ideas. Your response should include (a) an explanation and (b) a description of an experiment that would allow you to test out your explanation.

The liquid moves up the center tube with each swing of the bird. When the liquid reaches the top, the bird bends forward, releasing some of the liquid, but the liquid stays at the halfway point of the tube when it is restored. There must be some kind of tension that "sucks" the liquid up towards the head. It is as the head goes back that the liquid goes up the tube. As the head and bottom tube are perpendicular to the table, some of the liquid stays in the head and some goes into the bottom bulb. As the liquid enters the bottom bulb, the weight is shifted, causing the tilting to begin again. The tilting may remove pressure from the head, causing the liquid to move up the tube, like as straw.

I would like to flip the bird over and observe the liquid, see how it fills the head and tube. I would also like to try and recreate the situation (set it up again). Then I would slow the process down by holding the bird in one position at a time to observe the changes step by step.
3. The water in the atmosphere participates in a number of processes that affect the overall behavior of what we call "the weather". In the summer, air near the ground warms during the day and rises because it is less dense. As it does so, the air mass typically cools off, eventually leading to formation of small water droplets (clouds). How is the air in the clouds and cloud behavior affected? 

\[ \text{gas} \rightarrow \text{liquid} \]

**Kinetic energy transfer - lift instability**

As the air cools off and changes from a liquid to a gas, kinetic energy is transferred from the gas (H₂O) molecule to the air, making the air warmer and water droplets cooler.

4. Most metals and most liquids expand when the temperature rises. Suggest a sound explanation for this observation that would convince a scientist that you knew what you talking about.

To explain this phenomenon, you would have to look at the metals and liquids at a molecular level. In the solid phase, the molecules assume a particular pattern and the movement of the molecules is very little, the molecules stay in their shape. As heat is added and the solid is melted to become a liquid, the molecules do not have a particular pattern to form, the molecules also begin moving more. As heat is added the molecules attain more kinetic energy and move around even more. As a gas, the molecules assume the shape and volume of their container. To explain why most metals and liquids expand when the temperature rises, you would have to look between these phase changes as the molecules are attaining more energy and begin to take up more space.
5. Some plastic kitchenware is "dishwasher safe" and some is not. It's not about whether the stuff will dissolve, it's about the drying cycle. Some plastics will melt. There are two types of polyethylene, both of which consist entirely of long strands of carbon atoms to which are attached hydrogen atoms. Which type is dishwasher safe and why do you think so?

<table>
<thead>
<tr>
<th>Each end and corner represents a C atom. For example,</th>
<th>is</th>
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</table>

Type A looks like this:

Type B looks like this:

I would think Type A is dishwasher safe because it is an organized chain with carbon-hydrogen bonds that are strong and may be stronger than the bonds of Type B which are not only carbon-hydrogen bonds and have a less organized structure, perhaps affecting the bond between the molecules, since the pattern is not so straight and orderly.

6. Ammonia is the substance NH₃

Sketch a picture of droplet of liquid ammonia in the middle box. Then sketch what you think it would look like if it turned into solid form, and turned into the gaseous form. No verbal explanations.
Multiple Choice plus Explain [ 5 pts each ]

7. If we ever found a humanoid civilization on another planet (with the same level of technological development), we would expect the following to be the same:
   
   a. the melting point of ice relative to absolute zero
   b. the melting point of mercury relative to absolute zero
   c. the ratio of the melting points of ice and mercury relative to absolute zero
   d. the temperature of absolute zero

   Reason for choice:
   
   The presence of water on any planet allows for thought of extraterrestrial life, but in order for humans, or human-like creatures to exist, the behavior of water must be similar for the survival of the creatures.

8. If you were to design a thermometer, you would likely want to use a liquid that has
   
   a. a low melting point, and a high boiling point
   b. a high melting point, and a low boiling point
   c. a low melting point, and a low boiling point
   d. a high melting point, and a high boiling point

   Reason for choice:
   
   This way you could measure the extremes. If your liquid in the thermometer freezes, then you can't measure the temperature, same with boiling. If you have a liquid that is on both ends of the extreme, then you can have a larger range of measurement.

9. When we discussed thermosensitive neurons, we discussed
   
   a. that a stronger sensation is indicated by more rapid firing of action potentials
   b. that different neurons respond to colder temperature than to warmer temperatures
   c. that certain chemical substances unrelated to temperature can trigger the neurons
   d. that thermosensitive neurons get more active after longer exposure

   Reason for choice:
   
   This is the explanation for spicy foods to cause a hot sensation or minty gum to produce a cold sensation, even if these foods may be at room temperature.
10. An action potential in a nerve cell involves
   a. pores in the cell membrane that open and close
   b. ions of different types that move from inside the cell to outside, or the reverse
   (C) a voltage difference across the cell membrane that moves along the membrane
   d. a build up of thermal energy inside the nerve cell

   Reason for choice:
   An action potential allows a signal to be passed from neuron to neuron, and as one neuron depolarizes, then repolarizes, the signal is passed.

11. Perhaps you were prepared to respond to a question I did not ask.

   Write down that question, and explain why that would be a good question. You don’t have to provide an answer to that question.  Emporitive Cooing

   Why was ice able to be made in the East Indies if the temperature never reached freezing point?

   Good question because: its another topic of phase change and the transfer of energy.