Define the following vocabulary terms:

1. Exothermic –
2. Endothermic –
3. Kinetic energy –
4. Potential energy –
5. Heat –
6. Temperature –
7. Specific heat capacity –
8. Vaporization/boiling –
9. Freezing/solidification –
10. Melting/fusion –
11. Condensation –
12. Molar heat of fusion –
13. Molar heat of solidification –
14. Molar heat of vaporization –
15. Molar heat of condensation –

HEATING CURVE

16. DRAW THE HEATING CURVE OF WATER AND LABEL THE FOLLOWING ON YOUR DIAGRAM:

- melting                  - solid
- boiling point           - liquid
- freezing point          - gas
- condensation point

- kinetic energy is increasing
- kinetic energy is decreasing
- kinetic energy is constant

- potential energy is constant
- potential energy is increasing
- potential energy is decreasing

GAS KE changing PE constant
LIQUID KE changing PE constant
SOLID KE changing PE constant
MELTING POINT FREEZING POINT KE CONSTANT PE CHANGING
BOILING POINT CONDENSATION POINT KE CONSTANT PE CHANGING
17. Fill in the table below with what phase change is happening and whether it is endothermic or exothermic.

<table>
<thead>
<tr>
<th>PHASE CHANGE</th>
<th>PHASE TRANSITION</th>
<th>ENDO/EXO?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melting/Fusion</td>
<td>Solid – liquid</td>
<td>endothermic</td>
</tr>
<tr>
<td>Boiling/Vaporization</td>
<td>Liquid - gas</td>
<td>endothermic</td>
</tr>
<tr>
<td>Condensation</td>
<td>Gas-liquid</td>
<td>exothermic</td>
</tr>
<tr>
<td>Solidification/Freezing</td>
<td>Liquid - solid</td>
<td>exothermic</td>
</tr>
</tbody>
</table>

18. Which state of matter has the highest kinetic energy? Which state of matter has the lowest kinetic energy?

Gas particles have the highest temperature, therefore the highest kinetic energy. Gas particles have a great deal of movement/kinetic energy which is why particles can spread far apart and move in a chaotic fashion. Solid particles have the lowest temperature, therefore the lowest kinetic energy. Solid particles have no movement (translational energy), but vibrate in a fixed position.

19. Fill in the chart to compare endothermic and exothermic processes

<table>
<thead>
<tr>
<th></th>
<th>ENDOTHERMIC</th>
<th>EXOTHERMIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition/Heat flow</td>
<td>Absorbs heat energy</td>
<td>Loses/releases heat energy</td>
</tr>
<tr>
<td></td>
<td>Heat flows in</td>
<td>Heat flows out/away</td>
</tr>
<tr>
<td>q/ΔH value (positive or negative)</td>
<td>+Q +ΔH</td>
<td>-Q -ΔH</td>
</tr>
<tr>
<td>Temperature of System Change</td>
<td>+ ΔT (temp increases)</td>
<td>- ΔT (temp decreases)</td>
</tr>
</tbody>
</table>

TRUE/FALSE

If the statement is false, correct it/explain why it is false.

20. Sand absorbing sunlight is an exothermic process. FALSE, endothermic

21. Joules per gram x degree Celsius (J/g°C) is the unit used to measure heat energy absorbed. TRUE
22. Metal would make an excellent material to construct a calorimeter. **FALSE**, metal would conduct heat away from the system, or conduct heat from surrounding environment into experimental system. An insulator like Styrofoam is better to reduce heat loss or gain.

23. Water has a high specific heat. **TRUE**

24. Air has a high specific heat. **TRUE**, while not as high as water, air has a high specific heat then metals

25. Exothermic processes have a +q. **FALSE**, **NEGATIVE** Q showing the energy is going away, or lost

26. A 100 g sample of H₂O and a 10 g sample of H₂O will require the same amount of energy to boil. **FALSE**, A LARGER MASS WILL REQUIRE MORE HEAT ENERGY (BATH TUB VS. SWIMMING POOL)

27. Cooking food is an exothermic process. **FALSE**, FOOD IS ABSORBING HEAT ENERGY SO ENDOThERMIC

28. Heat moves from a warmer object to a colder object. **TRUE**

29. Q is the symbol used for mass. **FALSE**, M IS THE SYMBOL FOR MASS. Q IS THE SYMBOL FOR QUANTITY OF ENERGY

**SPECIFIC HEAT**

30. What is the equation for specific heat? Complete the table based on the equation.

\[ Q = mc\Delta T \]

Use the table below to answer questions 30-32.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Specific Heat (J/g°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>4.184</td>
</tr>
<tr>
<td>Carbon</td>
<td>0.71</td>
</tr>
<tr>
<td>Gold</td>
<td>0.13</td>
</tr>
<tr>
<td>Silver</td>
<td>0.23</td>
</tr>
</tbody>
</table>

31. What is the specific heat of a substance that absorbs 2516 J of energy as it changes from 26.9 °C to 45.6 °C? The mass of the substance is 1.71 grams.

\[ Q = mc\Delta T \]

\[ 2516 \text{ J} = (1.71 \text{ g})C (45.6 \text{ °C} - 26.9 \text{ °C}) \]

\[ C = 78.7 \text{ °C} \quad \text{wow, unusually large specific heat} \]
32. The specific heat of gold is 0.13 J/g°C. How much heat is needed to heat a 28.63 g sample from 35 °C to 96 °C?

\[ Q = mc \Delta T \]

\[ Q = 28.63 \text{ g} \times 0.13 \text{ J/g°C} \times (96 - 35) \]

\[ = 227.0 \text{ Joules} \]

ENERGY IS POSITIVE BECAUSE THE GOLD METAL IS GAINING HEAT

NOTE THE TEMP IS INCREASING FROM 35 TO 96

33. What is the final temperature of a 25 g sample of water that absorbs 2134 Joules of energy? The initial sample of water is 22° C?

\[ Q = mc \Delta T \]

\[ 2134 \text{ Joules} = 25 \text{ g} \times 4.184 \text{ J/g°C} \times (t_f - 22 °C) \]

\[ 2134 = 104.5 \times (t_f - 22 °C) \]

\[ 20.42 = t_f - 22 °C \]

\[ t_f = 42.42 °C \]

really important to pay attention if gain or loss of energy

because that affects if +2134 J or -2134 J

34. What is the equation to solve for heat change during a phase change? Fill in the box to the right.

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>MEASUREMENT</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Q ) or ( \Delta H )</td>
<td>Change in heat energy</td>
<td>KJ</td>
</tr>
<tr>
<td>( n )</td>
<td>Amount of substance</td>
<td>moles</td>
</tr>
<tr>
<td>( \Delta H_{\text{fus}} ) OR ( \Delta H_{\text{vap}} )</td>
<td>Constant, molar heat of fusion if melting/freezing Molar heat of vaporization if boiling/condensing</td>
<td>KJ/mol</td>
</tr>
</tbody>
</table>

Use the table to answer questions 34-38.

<table>
<thead>
<tr>
<th>Substance</th>
<th>( \Delta H_{\text{fus}} ) (kJ/mol)</th>
<th>( \Delta H_{\text{vap}} ) (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia (NH₃)</td>
<td>5.65</td>
<td>23.4</td>
</tr>
<tr>
<td>Hydrogen (H₂)</td>
<td>0.12</td>
<td>0.90</td>
</tr>
<tr>
<td>Methanol (CH₃OH)</td>
<td>3.16</td>
<td>35.3</td>
</tr>
<tr>
<td>Water (H₂O)</td>
<td>6.01</td>
<td>40.7</td>
</tr>
</tbody>
</table>

35. What is the change in energy required to melt 12.6 moles of methanol?

\[ \Delta H = n \Delta H_{\text{fus}} \]

\[ (12.6 \text{ moles})(3.16 \text{ KJ/mol}) = 39.8 \text{ KJ} \]

36. How many moles of hydrogen can be vaporized by 14.5 KJ of energy?

\[ \Delta H = n \Delta H_{\text{vap}} \]

\[ 14.5 \text{ KJ} = n (0.90 \text{ KJ/mol}) \]

\[ n = 16.1 \text{ moles of H}_2 \]

37. What is the change in energy required to vaporize 78 grams of water?

\[ 78 \text{ grams H}_2\text{O} \times \frac{1 \text{ mole H}_2\text{O}}{18 \text{ g H}_2\text{O}} = 4.3 \text{ moles H}_2\text{O} \]

\[ \Delta H = n \Delta H_{\text{vap}} \]

\[ (4.3 \text{ moles H}_2\text{O})(40.7 \text{ KJ/mol}) = 176.4 \text{ KJ} \]

38. How many moles of liquid ammonia can be converted to a solid when 92.3 kJ are lost?

\[ \Delta H = n \Delta H_{\text{fus}} \]

\[ -92.3 \text{ KJ} = n (-5.65 \text{ KJ/mol}) \]

\[ n = 16.3 \text{ moles of NH}_3 \]

Use negative values for energy and constant because ammonia is cooling/freezing, so losing energy

39. What is the change in energy required to condense 17.34 moles of ammonia?

\[ \Delta H = n \Delta H_{\text{vap}} \]

\[ (17.34 \text{ moles NH}_3)(-23.4 \text{ KJ/mol}) = -405.8 \text{ KJ} \]