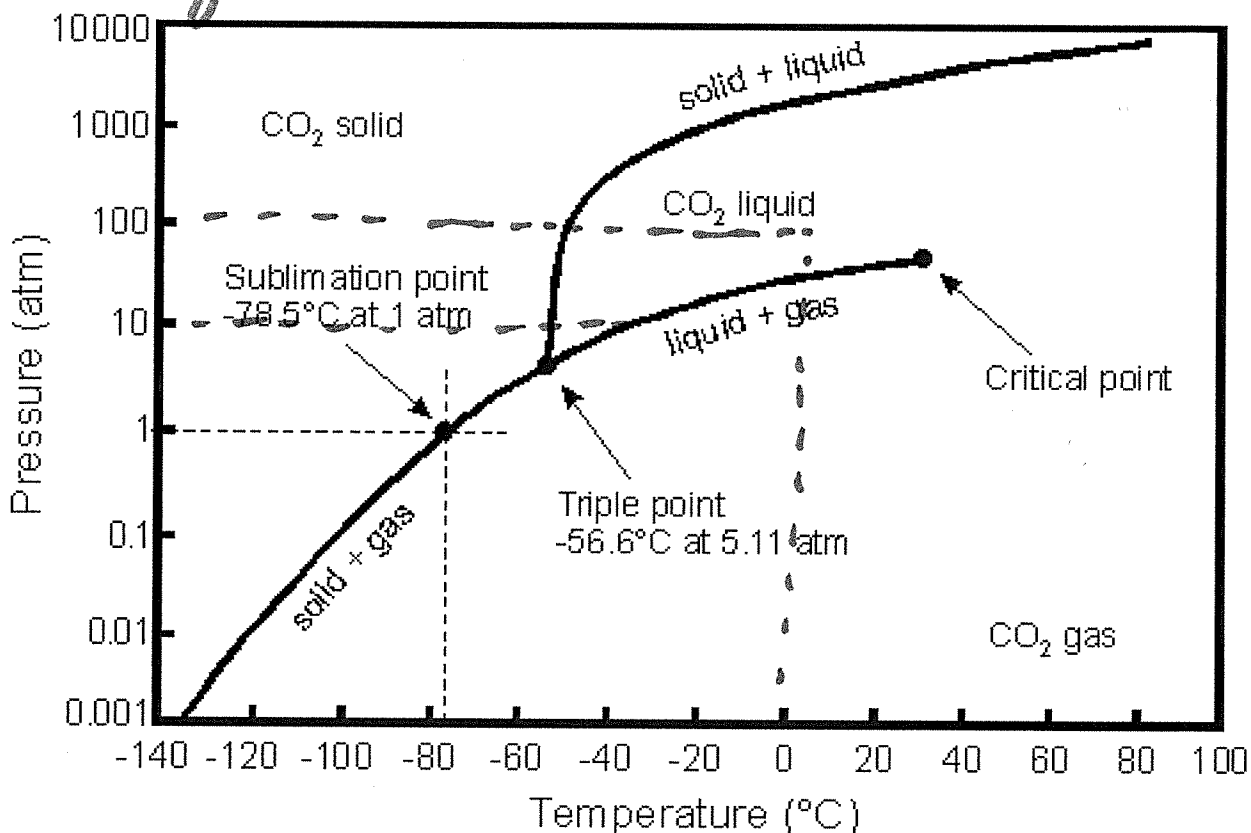# FPS – Thermal Energy & Specific Heat Practice

Name___*Key*___ Period_____

Pressure-Temperature phase diagram for CO_2.

1. Above is the phase diagram for CO_2. Answer the questions using the diagram.
   a. What is the sublimation point?

   Solid → gas @ -78.5°C at 1 atm (normal)

   b. At 100 atm of pressure and -120 degrees Celsius, you have dry ice (solid CO_2). You raise the temperature rapidly to 0 degrees Celsius. What phase change occurs?
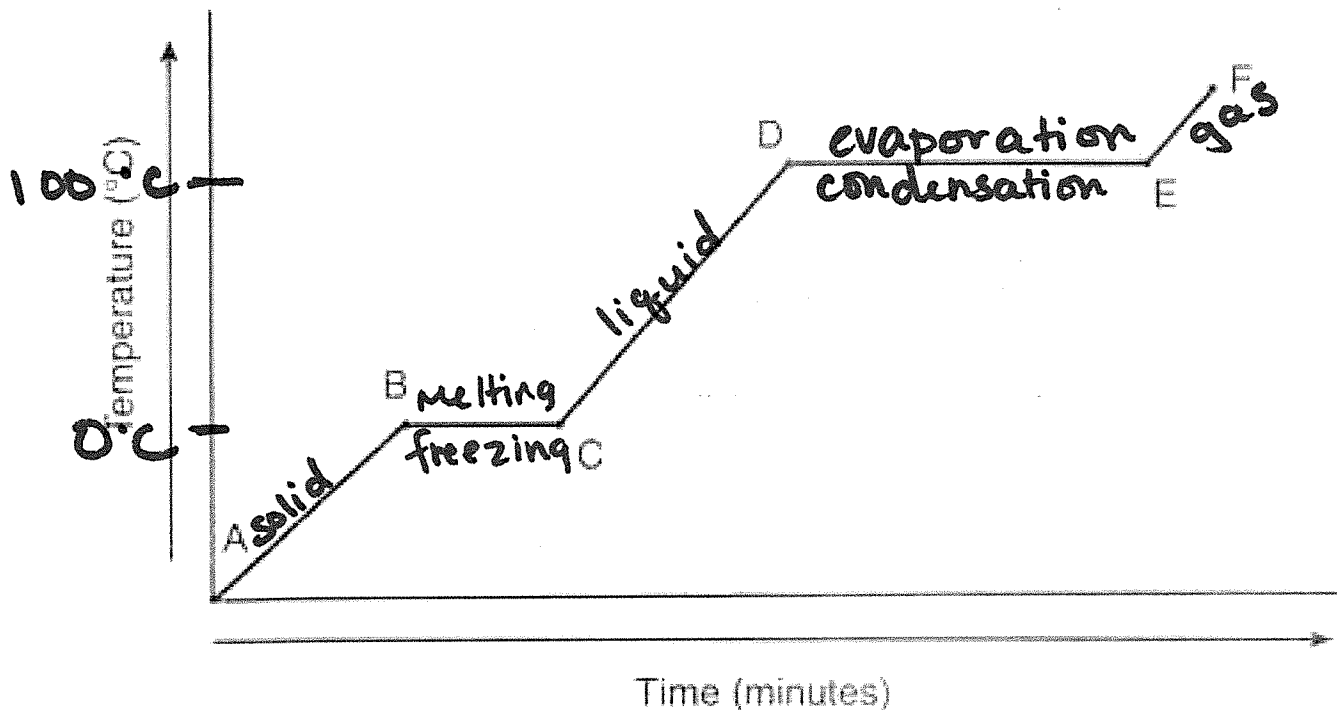
   Solid → liquid   melting!

   c. At what pressure and temperature are all three states in equilibrium?

   Triple point; -56.6°C at 5.11 atm

   d. At 10 atm of pressure, what temperature changes could cause evaporation?

   liquid ⟶ gas
   ~ -50°C to -35°C   ~ -35°C and up

2. Label the heating curve below for **water**; indicate the states of matter for each diagonal line, the phase changes, and the temperatures for each.

Temperature (°C) vs Time (minutes)

$100°C$ —
$0°C$ —

D evaporation / gas
condensation E   F

liquid

B melting
freezing C

A solid

Time (minutes)

3. Below is the formula for calculating heat. Label the variables and their units.

$$Q = m \; c \; \Delta T \longrightarrow \text{change in temp} \; (°C)$$

heat (J)
mass (g or kg)
specific heat ($J/g°C$ or $J/kg°C$)

4. Heat is not the same as temperature, yet they are related. Explain how they differ from each other.

Heat is the transfer of thermal energy; temperature is a measurement of heat — specifically the average kinetic energy of the particles in an object.

5. Gold has a specific heat of 0.129 J/g°C. How many joules of heat are required to raise the temperature of 15 grams of gold from 22°C to 85°C?

$m = 15g$
$c = 0.129 \, J/g°C$
$\Delta T = 85 - 22 = 63°C$

$Q = mc\Delta T$
$= (15)(.129)(63) = 121.905 \; J$

6. An unknown substance with a mass of 100 grams absorbs 1000 J while undergoing a temperature increase of 15 °C. What is the specific heat of the substance?

$Q = 1000 \, J$
$m = 100g$
$\Delta T = 15°C$

$Q = mc\Delta T$
$c = \dfrac{Q}{m\Delta T} = \dfrac{1000 \, J}{(100)(15)} = 0.67 \, J/g°C$

7. If the temperature of 34.4 g of ethanol increases from 25 °C to 78.8 °C, how much heat has been absorbed by the ethanol? The specific heat of ethanol is 2.44 J/(g×°C)

$m = 34.4 g$
$\Delta T = 78.8 - 25 = 53.8 °C$
$c = 2.44 \, \text{J/g°C}$

$Q = mc\Delta T$
$= (34.4)(2.44)(53.8)$
$= 4515.76 \, J$

8. Graphite has a specific heat of 0.709 J/(g×°C). If a 25 gram piece of graphite is cooled from 35 °C to 18 °C, how much energy was lost by the graphite?

$c = 0.709 \, \text{J/g°C}$
$m = 25 g$
$\Delta T = ~~~~~ 18 - 35 = -17°C$

$Q = mc\Delta T$
$= (25g)(0.709)(-17°C) = -301.3 \, J$

9. Copper has a specific heat of 0.385 J/(g×°C). A piece of copper absorbs 5000 J of energy and undergoes a temperature change from 100 °C to 200 °C. What is the mass of the piece of copper?

$c = 0.385 \, \text{J/g°C}$
$Q = 5000 J$
$\Delta T = 200 - 100 = 100°C$

$Q = mc\Delta T$
$m = \frac{Q}{c\Delta T} = \frac{5000 J}{(.385)(100)} = 129.9 \, g$

10. 45 grams of an unknown substance undergoes a temperature increase of 38 °C after absorbing 4172.4 Joules. What is the specific heat of the substance?

$m = 45 g$
$\Delta T = 38°C$
$Q = 4172.4 J$

$Q = mc\Delta T$
$c = \frac{Q}{m\Delta T} = \frac{4172.4 \, J}{(45g)(38°C)} = 2.44 \, \text{J/g°C}$

11. A 40 g sample of water absorbs 500 Joules of energy. How much did the water temperature change? The specific heat of water is 4.18 J/(g×°C).

$m = 40 g$
$Q = 500 J$
$c = 4.18 \, J/g°C$

$Q = mc\Delta T$
$\Delta T = \frac{Q}{mc} = \frac{500 J}{(40)(4.18)} = 2.99 \approx 3°C$

12. If 335 g of water at 65.5 °C loses 9750 J of heat, what is the final temperature of the water? Liquid water has a specific heat of 4.18 J/(g×°C).

$m = 335 g$
$Q = -9750 J$
$c = 4.18 \, \text{J/g°C}$

$Q = mc\Delta T$
$\Delta T = \frac{Q}{mc} = \frac{9750 J}{(335)(4.18)} = 6.96°C$

$\Delta T = T_f - T_i$
$(6.96°C) = x - 65.5°C$
$T_f = 72.5°C$

13. A 15.75-g piece of iron absorbs 1086.75 joules of heat energy, and its temperature changes from 25°C to 175°C. Calculate the specific heat capacity of iron.

$m = 15.75 g$
$Q = 1086.75 J$
$\Delta T = 175 - 25 = 150°C$

$Q = mc\Delta T$
$c = \frac{Q}{m\Delta T} = \frac{1086.75}{(15.75)(150)} = 0.46 \, \text{J/g°C}$

14. How many joules of heat are needed to raise the temperature of 10.0 g of aluminum from 22°C to 55°C, if the specific heat of aluminum is 0.90 J/g°C?

$m = 10.0$ g

$\Delta T = 55 - 22 = 33°C$

$C = 0.90 \text{ J/g°C}$

$Q = mc\Delta T$
$= (10)(0.90)(33)$
$= 297$ J

15. To what temperature will a 50.0 g piece of glass raise if it absorbs 5275 joules of heat and its specific heat capacity is 0.50 J/g°C? The initial temperature of the glass is 20.0°C.

$m = 50.0$ g

$Q = 5275$ J

$C = 0.50$ J/g°C

$Q = mc\Delta T$

$\Delta T = \dfrac{Q}{mc} = \dfrac{5275}{(50)(.50)} = 211°C$

$\Delta T = T_f - T_i$

$211°C = T_f - 20$

$T_f = 231°C$

16. Calculate the heat capacity of a piece of wood if 1500.0 g of the wood absorbs 6.75×10⁴ joules of heat, and its temperature changes from 32°C to 57°C.

$m = 1500.0$ g

$Q = 67500$ J

$\Delta T = 57 - 32 = 25$

$Q = mc\Delta T$

$C = \dfrac{Q}{m\Delta T} = \dfrac{67500}{(1500)(25)} = 1.8$ J/g°C

17. 100.0 mL of 4.0°C water is heated until its temperature is 37°C. If the specific heat of water is 4.18 J/g°C, calculate the amount of heat energy needed to cause this rise in temperature.

$m = 100$ mL $= 100$ g

$\Delta T = 37 - 4 = 33°C$

$C = 4.18$ J/g°C

$Q = mc\Delta T = (100)(4.18)(33)$
$= 13794$ J

18. 25.0 g of mercury is heated from 25°C to 155°C, and absorbs 455 joules of heat in the process. Calculate the specific heat capacity of mercury.

$m = 25.0$ g

$\Delta T = 155 - 25 = 130°C$

$Q = 455$ J

$Q = mc\Delta T$

$C = \dfrac{Q}{m\Delta T} = \dfrac{455 J}{(25)(130)} = 0.14$ J/g°C

19. If a sample of chloroform is initially at 25°C, what is its final temperature if 150.0 g of chloroform absorbs 1.0 kilojoules of heat, and the specific heat of chloroform is 0.96 J/g°C? units are not matching!! (Makes a good bonus...)

$m = 150.0$ g

$Q = 1.0$ KJ $\times 1000 = 1000$ J

$\Delta T = T_f - T_i$

$C = 0.96$ J/g°C

$Q = mc\Delta T$

$\Delta T = \dfrac{Q}{mc} = \dfrac{1000 J}{(150)(0.96)} = 6.94°C$

$\Delta T = T_f - T_i$

$(6.94) = T_f - 25$ → $T_f = 31.9°C$