Honors Chemistry – Unit 5 Review

KEY

Chapter 13 – States of Matter

Vocabulary – Use with Questions 1-16

normal boiling point
Avogadro's hypothesis
atmospheric pressure
vapor pressure
unit cell
vaporization
boiling point
super-cooled liquid
crystal
amorphous
barometer
kinetic theory
melting point
phase change
sublimation
evaporation

1. AVOGADRO'S HYPOTHESIS states that equal volumes of gases at the same temperature and pressure contain equal numbers of particles.
2. A BAROMETER is a device used to measure atmospheric pressure.
3. MELTING POINT is the temperature at which a solid turns into liquid.
4. A SUPER COOLED LIQUID is a substance that has cooled to a rigid state without crystallizing.
5. The pressure resulting from the collision of air molecules with objects is called ATMOSPHERIC PRESSURE
6. The temperature at which the vapor pressure of a liquid is just equal to the external pressure is called BOILING POINT.
7. AMORPHOUS is a form of solid lacking an ordered internal structure.
8. A CRYSTAL is a solid in which the atoms, ions, or molecules are arranged in an orderly pattern.
9. The pressure above a liquid in a sealed container caused by collision of vaporized particles with the walls of the container is called VAPOR PRESSURE.
10. The smallest group of particles within a crystal that retains the shape of the crystal is called the UNIT CELL.
11. NORMAL BOILING POINT is the boiling point of a liquid at a pressure of 1 atm.
12. A change that occurs when the physical state of a substance changes is called a PHASE CHANGE.
13. The evaporation of an uncontained liquid is called VAPORIZATION.
14. The KINETIC THEORY states that tiny particles in all forms of matter are in constant motion.
15. The conversion of a liquid to a gas below the boiling point is called EVAPORATION.
16. The direct change of a substance from a solid to a gas is called SUBLIMATION.

Concepts

1. Most solids…
   [✓ a)] are dense and incompressible
   b) have low melting points
   c) are amorphous in nature
   d) consist of particles in random motion
2. The escape of gas molecules from the surface of an uncontained liquid is known as:
   a) boiling b) sublimation [✓ c)] evaporation d) condensation
3. The pressure of a gas in a container is 152 mm Hg. This is equivalent to:
   $\frac{152\,mmHg}{1} \Big| \frac{1atm}{760\,mmHg} = 0.2\,atm$
   [✓ a)] 0.2 atm SF not correct b) 2 atm c) 0.3 atm d) 0.4 atm
4. Standard conditions when working with gases are defined as:
   a) 0 K and 1 atm b) 0 K and 1 mmHg [✓ c)] 0°C and 1 atm d) 0°C and 1 mm Hg
5. The temperature at which the motion of particles theoretically ceases is:
   a) -273 K [✓ b)] 0 K c) 0°C d) 273°C
6. The average kinetic energy of the particles of a substance is:
   a) not affected by the temperature of the substance
   b) raised as the temperature of the substance is lowered
   [✓ c)] proportional to the temperature of the substance
   d) equal to the total thermal energy absorbed by the substance

Chapter 17 – Thermochemistry

1. Convert from one unit to the other:

a. 1.69 Joules to calories

$$\frac{1.69\,J}{1}\left|\frac{1.00\,cal}{4.18\,J}\right. = \boxed{0.404\,cal}$$

c. 68 calories to kilocalories

$$\frac{68\,cal}{1}\left|\frac{1\,kcal}{1000\,cal}\right. = \boxed{0.068\,Kcal}$$

b. 820.1 J to kilocalories

$$\frac{820.1\,J}{1}\left|\frac{1.00\,cal}{4.18\,J}\right|\frac{1\,kcal}{1000\,cal} = \boxed{0.1960\,Kcal}$$

d. 20.0 calories to Joules

$$\frac{20.0\,cal}{1}\left|\frac{4.18\,J}{1.00\,cal}\right. = \boxed{83.7\,J}$$

2. Determine the energy required (in Joules) when the temperature of 3.21 grams of water increases by 4.0 °C while remaining liquid.

* temp. change *

$\Delta H = mc_p\Delta T$

$\Delta H = 3.21g * 4.18\frac{J}{g°c} * 4°c$

$\boxed{\Delta H = \oplus\, 54\,J}$

3. Determine the energy required (in kilojoules) when cooling 456.2 grams of water at 89.2 °C to a final temperature of 5.9 °C.

* temp. change *

$\Delta H = mc_p\Delta T$

$\Delta H = 456.2g * 4.18\frac{J}{g°c} * (5.9°c - 89.2°c)$

$\boxed{\begin{array}{l}\Delta H = \ominus 158{,}846\,J \text{ OR} \\ \Delta H = \ominus 159\,KJ\end{array}}$

4. Determine the energy required to boil 0.345 moles of water at 100.0 °C.

* phase change *

$\Delta H = mol \cdot \Delta H_{vap}$

$\Delta H = 0.345\,mol \cdot \oplus 40.7\frac{KJ}{mol}$

$\boxed{\Delta H = \oplus\, 14.0\,KJ}$

5. Determine the energy required to melt 74.5 grams of ice at 0.0 °C.

* phase change *

$\Delta H = mol \cdot \Delta H_{fus}$

$$\frac{74.5g\,H_2O}{1}\left|\frac{1mol\,H_2O}{18.02g\,H_2O}\right. = 4.13\,mol \cdot 6.02\frac{KJ}{mol}$$

$\boxed{\Delta H = \oplus\, 24.9\,KJ}$

6. Determine the specific heat of a 150.0 gram object that requires 62.0 cal of energy to raise its temperature 12.0 °C.

* temp. change *

$\Delta H = mc_p\Delta T$

$62\,cal = 150.0g \cdot C_p \cdot 12°c$

$\boxed{C_p = 0.0344\frac{cal}{g°c}}$

7. When 80.0 grams of a certain metal at 90.0 °C was mixed with 100.0 grams of water at 30.0°C, the final equilibrium temperature of the mixture was 36.0 °C. What is the specific heat (J/ g°C) of the metal?

* make list *

metal

$m = 80.0g$

$C_p = ?$

$T_i = 90.0°C$

$T_f = 36.0°C$

water

$m = 100.0g$

$C_p = 4.18\frac{J}{g°c}$ or $1.00\frac{cal}{g°c}$

$T_i = 30°c$

$T_f = 36°c$

$\Delta H_{\text{lost by metal}} = \Delta H_{\text{gained by water}}$

Solve for ΔH_{water} → $\Delta H = mc\Delta T$

$\Delta H = 100 \cdot 4.18 \cdot 6$

$\Delta H = \oplus\, 2508\,J\ (600\,cal)$

$\Delta H_{metal} = \ominus 2508\,J\ (\ominus 600\,cal)$

Solve for c_p metAL → $\Delta H = mc_p\Delta T$

$-2508 = 80 \cdot c \cdot {-54}$

$\boxed{C_p = 0.581\frac{J}{g°c} \text{ or } 0.139\frac{cal}{g°c}}$

8. A piece of aluminum with a mass of 80.0 g at a temperature of 70.0°C is dropped into an insulated container which contains 250.0 mL water. The temperature of the water before adding the iron is 25.0°C. The final temperature of the mixture is 28.5°C What is the specific heat capacity of the aluminum?

$\downarrow d_{H_2O} = 1.00\,g/mL$

* make list *

metal (Al)

$m = 80.0g$

$c_p =$

$T_i = 70.0°C$

$T_f = 28.5°C$

water

$m = 250.0g$

$C_p = 4.18\,J/g°c$ or $1.00\,cal/g°c$

$T_i = 25.0°c$

$T_f = 28.5°C$

$\Delta H_{\text{lost by Al}} = \Delta H_{\text{gained by }H_2O}$

Solve for ΔH_{water} → $\Delta H = mc\Delta T$

$\Delta H = 250.0 \cdot 4.18 \cdot (28.5 - 25.0)$

$\Delta H = \oplus 3658\,J\ (\oplus 875\,cal)$

ΔH_{Al} → $\Delta H = \ominus 3658\,J\ (\ominus 875\,cal)$

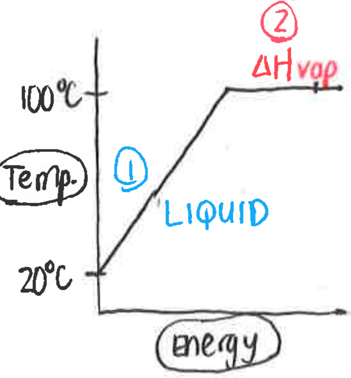
Solve for c_p Al → $\Delta H = mc_p\Delta T$

$\ominus 3658 = 80 \cdot c_p \cdot (28.5 - 70)$

$\boxed{C_p = 1.10\frac{J}{g°c} \text{ or } 0.264\frac{cal}{g°c}}$

9. How much energy is required to convert 100.0 g of water at 20.0 °C completely to steam at 100.0 °C?

* temp. change & phase change *



① Temp. change

$\Delta H = mc_p \Delta T$

$\Delta H = 100g \cdot 4.18 \frac{J}{g°C} \cdot (100-20)$

$\underline{\Delta H_1 = \oplus 33440\,J \text{ or } \oplus 33.44\,kJ}$

② phase change

$\Delta H = mol \cdot \Delta H_{vap}$

$\frac{100\,g\,H_2O}{1} \Big| \frac{1\,mol}{18.02\,g} = 5.55\,mol$

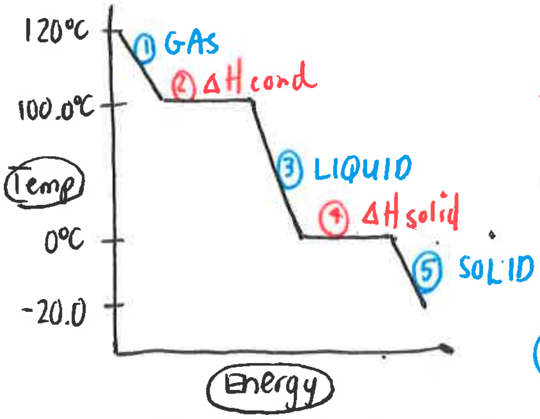
$\Delta H = 5.55\,mol \cdot 40.7 \frac{kJ}{mol}$

$\underline{\Delta H_2 = \oplus 225.9\,kJ}$

ADD UP FOR TOTAL ENERGY ⇒ $\Delta H_T = \Delta H_1 + \Delta H_2 = \oplus 33.44\,kJ + 225.9\,kJ = \boxed{\Delta H_{Total} \overset{\oplus}{=} 259.3\,kJ}$

10. Calculate the energy released when 10.0 g of steam at 120.0 °C are converted into ice at the –20.0 °C.

* temp. change & phase change *



① $\Delta H = 10.0g * 2.02 \frac{J}{g°C} \cdot \ominus 20°C = \ominus 404\,J$ or $\underline{\ominus 0.404\,kJ}$

② $\Delta H = \frac{10.0g}{1} \Big| \frac{1\,mol}{18.02g} = 0.555\,mol \cdot \ominus 40.7 \frac{kJ}{mol} = \underline{\ominus 22.6\,kJ}$

③ $\Delta H = 10.0g \cdot 4.18 \frac{J}{g°C} \cdot \ominus 100°C = \ominus 4180\,J$ or $\underline{\ominus 4.18\,kJ}$

④ $\Delta H = 0.555\,mol \cdot \ominus 6.02 \frac{kJ}{mol} = \underline{\ominus 3.34\,kJ}$

⑤ $\Delta H = 10.0g \cdot 2.06 \frac{J}{g°C} \cdot \ominus 20°C = \ominus 412\,J$ or $\underline{\ominus 0.412\,kJ}$

ADD FOR TOTAL

$\boxed{\Delta H_{Tot} = \ominus 30.9\,kJ}$

11. Given the following reaction:

$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3 \quad \Delta H = -848.1\ kJ$

a. Is the reaction endothermic or [✓ exothermic]? b/c ΔH is ⊖

b. Write the thermochemical equation.

$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3 + 848.1\,kJ$

c. You have 22.7 g of iron (III) oxide. How much heat is released when the iron (III) oxide reacts with excess aluminum?

$\frac{22.7g\,Fe_2O_3}{1} \Big| \frac{1\,mol\,Fe_2O_3}{159.12\,g\,Fe_2O_3} \Big| \frac{848.1\,kJ}{1\,mol\,Fe_2O_3} = \boxed{\ominus 121\,kJ \text{ released}}$

from balanced equation

d. How many grams of iron are produced when 224.3 kJ of energy are released?

$\frac{224.13\,kJ}{1} \Big| \frac{2\,mol\,Fe}{848.1\,kJ} \Big| \frac{55.86\,g\,Fe}{1\,mol\,Fe} = \boxed{29.55\,g\,Fe}$

from balanced equation

12. Given the following reaction:

$$2SO_3 \rightarrow 2SO_2 + O_2 \quad \Delta H = +197.8 \text{ kJ}$$

a. Is the reaction [✓ endothermic] or exothermic? b/c ΔH is $\oplus$

b. Write the thermochemical equation.

$$2SO_3 + 197.8 \text{ KJ} \longrightarrow 2SO_2 + O_2$$

c. How many grams of SO_3 react when 575 kJ of heat is absorbed?

$$\frac{575 \text{ KJ}}{1} \left| \frac{2 \text{ mol } SO_3}{197.8 \text{ KJ}} \right| \frac{80.06 \text{ g } SO_3}{1 \text{ mol } SO_3} = \boxed{465.5 \text{ g } SO_3}$$

from balaneed equation

13. How much heat energy is released when 12.8 g of barium oxide react with excess sulfur trioxide?

$$BaO\ (s) + SO_3\ (g) \rightarrow BaSO_4\ (s) \quad \Delta H_{rxn}^{\circ} = -213.4 \text{ kJ}$$

$$\frac{12.8 \text{ g BaO}}{1} \left| \frac{1 \text{ mol BaO}}{153.3 \text{ g BaO}} \right| \frac{\ominus 213.4 \text{ kJ}}{1 \text{ mol BaO}} = \boxed{\ominus\ 17.8 \text{ KJ released}}$$

from balaneed equation

14. You can find the amount of heat evolved in the combustion of carbon by carrying out the reaction in a combustion calorimeter. You burn 0.300 g of carbon (graphite) in an excess of O_2 (g) to give CO_2 (g).

$$C\ (\text{graphite}) + O_2\ (g) \rightarrow CO_2\ (g)$$

The temperature of the calorimeter, which contains 775 g of water, increases from $\overset{t_i}{25}$°C to $\overset{t_f}{27.38}$°C. What quantity of heat is evolved per mole of carbon?

$$\oplus \Delta H_{\text{gained by water}} = \ominus\ \Delta H_{\text{lost by carbon}}$$

$$\Delta H_{water} = m c_p \Delta T$$

$$= 775 g \cdot 4.18 \frac{J}{g°C} \cdot (27.38 - 25)$$

$$\Delta H_{water} = \oplus 7710 \text{ J}$$

$$\Delta H_{carbon} = \ominus 7710 \text{ J}$$

Find moles of carbon → $\frac{0.300 \text{ g C}}{1} \left| \frac{1 \text{ mol C}}{12.01 \text{ g C}} \right. = 0.025 \text{ mol C}$

$$\Delta H = \frac{\ominus 7710 \text{ J}}{0.025 \text{ mol}} = \boxed{\ominus 308{,}400 \frac{J}{mol} \text{ or } \ominus\ 308.4 \frac{KJ}{mol}}$$