

Please read all the questions VERY carefully before answering. Ask your instructor if you don not understand. No outside paper is allowed. The last page is a periodic table with constants. Total points =  $70 + (28 * 3) = 84 = 154$

**SHORT ANSWER.** Please write the set-up equation first, then put the raw data with units before calculating. Write the word or phrase that best completes each statement or answers the question.

- 1) Calculate the amount (in grams) of sodium bicarbonate ( $\text{NaHCO}_3$ ) needed to react with enough acetic acid ( $\text{CH}_3\text{CO}_2\text{H}$ ) to produce 500.0 mL of carbon dioxide ( $\text{CO}_2$ ) gas at  $20^\circ\text{C}$  and 760 mmHg pressure. (MW of  $\text{NaHCO}_3 = 84 \text{ g/mol}$ ). The balanced chemical equation is:
- $$\text{NaHCO}_3 (\text{s}) + \text{CH}_3\text{CO}_2\text{H} (\text{aq}) \longrightarrow \text{CH}_3\text{CO}_2\text{Na} (\text{aq}) + \text{H}_2\text{O} (\text{l}) + \text{CO}_2 (\text{g}) \quad (8 \text{ pts.})$$

1) 1.75 g  $\text{NaHCO}_3$ 

$$PV = nRT$$

$$760 \text{ mmHg} \times \frac{1 \text{ atm}}{760 \text{ mmHg}} \times \frac{500.0}{1000} \text{ L} = n (0.0821 \frac{\text{L} \cdot \text{atm}}{\text{K} \cdot \text{mol}}) (273 + 20) \text{ K}$$

$$n = 0.0208 \text{ mol } \text{CO}_2$$

$$0.0208 \text{ mol } \text{CO}_2 \times \frac{1 \text{ mol } \text{NaHCO}_3}{1 \text{ mol } \text{CO}_2} \times \frac{84 \text{ g } \text{NaHCO}_3}{1 \text{ mol } \text{NaHCO}_3} = 1.745977 \text{ g}$$

$$\approx 1.75 \text{ g } \text{NaHCO}_3$$

- 2) A ball has a volume of  $120.3 \text{ cm}^3$  and it contains 0.25 g of  $\text{N}_2$  gas. Calculate the pressure inside the ball at  $31^\circ\text{C}$  (6 pts.)

2) 1.85 atm

$$\text{Moles of } \text{N}_2 \text{ gas} = \frac{0.25}{2(14.01)} = 0.008924 \text{ mol}$$

$$PV = nRT$$

$$P \left( \frac{120.3}{1000} \text{ L} \right) = 0.008924 \text{ mol} \left( 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{K} \cdot \text{mol}} \right) (273 + 31) \text{ K}$$

$$P = 1.851444 \text{ atm}$$

$$\approx 1.85 \text{ atm}$$

- 3) To determine the empirical formula of a compound made of Fe and Cl, a student added 2.15 g Zinc to a solution containing 1.750 g of  $\text{Fe}_x\text{Cl}_y$ . After the reaction was over, the student isolated 0.771 g of Fe. Use these data to answer the following questions (16 pts total):

- a) 0.979 g Cl  
b) 0.0138 mol Fe  
3) c) 0.0276 mol Cl  
d) 1:2  
e)  $\text{FeCl}_2$

- (a) Calculate the mass of Cl in the  $\text{Fe}_x\text{Cl}_y$  solution (2 pt.):

$$\text{mass of Cl} = (1.750 - 0.771) \text{ g} = 0.979 \text{ g}$$

- (b) Calculate the number of moles of Fe present in the  $\text{Fe}_x\text{Cl}_y$  solution (4 pt.):

$$\text{No. of moles of Fe} = \frac{0.771}{55.845} = 0.0138 \text{ mol}$$

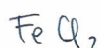
- (c) Calculate the number of moles of Cl present in the  $\text{Fe}_x\text{Cl}_y$  solution (4 pt.):

$$\text{No. of moles of Cl} = \frac{0.979}{35.453} = 0.0276 \text{ mol}$$

- (d) Determine the molar ratio of Fe to Cl in the compound (4pts.).

$$\begin{array}{l} \text{mol Fe} : \text{mol Cl} \\ \frac{0.0138}{0.0138} : \frac{0.0276}{0.0138} \\ 1 : 2 \end{array} \Rightarrow \text{The molar ratio of Fe to Cl is } \underline{1 : 2}$$

- (e) Use the above ratio to write the empirical formula of the compound containing Fe and Cl (2 pt.)



- 4) Calculate the volume of  $\text{NH}_3$  (g) in liters at  $729^\circ\text{C}$  and 4.5 atm pressure that is required to react with 2.52 moles of  $\text{O}_2$ (g) according to reaction,  $4 \text{NH}_3(\text{g}) + 5 \text{O}_2(\text{g}) \rightarrow 4 \text{NO}(\text{g}) + 6 \text{H}_2\text{O}(\text{g})$  (8 pts.)

4) 36.9 L

$$\begin{aligned} \text{No. of moles of NH}_3 &= 2.52 \text{ moles of O}_2 \times \frac{4 \text{ moles of NH}_3}{5 \text{ moles of O}_2} \\ &= 2.016 \text{ moles of NH}_3 \end{aligned}$$

$$PV = nRT$$

$$4.5 V = 2.016 (0.0821) (273 + 729)$$

$$V = 36.8543616 \text{ L}$$

$$V \approx 36.9 \text{ L}$$

- 5) Magnesium reacts with oxygen:  $\text{Mg} + \text{O}_2(\text{g}) \rightarrow 2\text{MgO}(\text{s})$ . How many grams of Magnesium would react with all the oxygen in a 87.4 L container at  $27^\circ\text{C}$  and  $3.5 \times 10^{-7}$  torr pressure? (8 pts.)

5)  $3.97 \times 10^{-8} \text{ g Mg}$

$$PV = nRT$$

$$\frac{3.5 \times 10^{-7}}{760} (87.4) = n (0.0821) (273 + 27)$$

$$n = 1.634 \times 10^{-9} \text{ mol O}_2$$

$$\text{No. of moles of Mg} = 1.634 \times 10^{-9} \text{ mol} \times \frac{2 \text{ mole Mg}}{1 \text{ mole O}_2}$$

$$\text{Mass of Mg} = 1.634 \times 10^{-9} \times 24.305 \times 2$$

$$= 3.971888957 \times 10^{-8} \text{ g}$$

$$\approx 3.97 \times 10^{-8} \text{ g} \times 2$$

$$= 7.9 \times 10^{-8} \text{ g}$$

-2

- 6) Oxygen gas is produced by decomposing  $\text{KClO}_3$  as follows:  $2\text{KClO}_3 \rightarrow 2\text{KCl}(\text{s}) + 3\text{O}_2(\text{g})$ . If 0.25 L of oxygen was collected over water at  $26^\circ\text{C}$  and 765 torr pressure, calculate the weight (in grams) of  $\text{KClO}_3$  decomposed. Vapor pressure of water at  $26^\circ\text{C}$  is 25 torr. (10 pts.)

6)  $0.810 \text{ g KClO}_3$

$$PV = nRT$$

$$\left( \frac{765 - 25}{760} \right) \text{ atm} \times 0.25 \text{ L} = n \left( 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{K} \cdot \text{mol}} \right) (273 + 26) \text{ K}$$

$$n = 0.009916 \text{ mol O}_2$$

$$\text{No. of moles of KClO}_3 = 0.009916 \text{ mol O}_2 \times \frac{2 \text{ mol KClO}_3}{3 \text{ mol O}_2} = 0.00661 \text{ mol KClO}_3$$

$$\text{Mass of KClO}_3 = 0.00661 \times (39.098 + 35.453 + 3 \times 15.999)$$

$$= 0.81014 \text{ g}$$

$$\approx 0.810 \text{ g}$$

- 7) One kilogram of water is cooled from 50°C to ice at 0°C. Calculate the amount of heat released. Given specific heat of water is 4.18 J g<sup>-1</sup> K<sup>-1</sup> and heat of fusion of ice = 6.01 kJ mol<sup>-1</sup>. (8 pts.)

7) 543 kJ

$$\begin{aligned}\Delta H &= mc\Delta T \\ &= 1000 \text{ g} (4.18 \text{ J/g}\cdot\text{K}) (273 - 323) \text{ K} + (-6.01 \text{ kJ/mol}) \left(\frac{1000}{18} \text{ mol}\right) \\ &= (-209000 - 333888.8889) \text{ J} \\ &= -542888.8889 \text{ J} \\ &\approx -543 \text{ kJ} \quad (\text{exothermic})\end{aligned}$$

∴ The amount of heat released is 543 kJ

- 8) Calculate the density (in g/L) of carbon tetrachloride at 714 torr and 125°C. (6 pts.)

8) 4.42 g/L

$$\begin{aligned}\text{density} &= \frac{m}{V} \\ PV &= nRT \\ \frac{714}{760} V &= \frac{m}{12.01 + 4 \times 35.453} (0.0821) (273 + 125) \\ \frac{m}{V} &= \frac{714}{760} (153.823) \left(\frac{1}{0.0821}\right) \left(\frac{1}{398}\right) \\ \text{density} &= 4.42262 \text{ g/L} \approx \underline{\underline{4.42 \text{ g/L}}}\end{aligned}$$

**MULTIPLE CHOICE.** On the scantron, fill up the circle with the same number as the question number. Choose the one alternative that best completes the statement or answers the question (3 pts each).

9) What type of a reaction occurs when a potassium nitrate solution is mixed with a barium acetate solution?

9) E

- A) oxidation-reduction ✗
- B) gas evolution ✗
- C) precipitation ✗
- D) acid-base neutralization ✗
- E) no reaction



10) What would be the formula of the precipitate that forms when  $Pb(NO_3)_2$  (aq) and  $K_2SO_4$  (aq) are mixed?

10) D

- A)  $K(NO_3)_2$
- B)  $PbK_2$
- C)  $H_2O$
- D)  $PbSO_4$
- E) none of the above

11) How many eggs are needed to make 1 dozen waffles, assuming you have enough of all other ingredients?

11) C

Given: 2 cups flour + 3 eggs + 1 tbs oil  $\rightarrow$  4 waffles

- A) 48
- B) 12
- C) 9
- D) 16
- E) not enough information

12) What is the theoretical yield of a reaction if 25.0 grams of product were actually produced from a reaction that has a 88% yield?

12) A

- A) 28.4
- B) 352
- C) 22.0
- D) 3.52
- E) none of the above

13) What is the limiting reactant for the following reaction given we have 2.6 moles of HCl and 1.4 moles of  $Ca(OH)_2$ ?

13) C

Reaction:  $2HCl + Ca(OH)_2 \rightarrow 2H_2O + CaCl_2$

- A)  $CaCl_2$
- B)  $Ca(OH)_2$
- C) HCl
- D)  $H_2O$
- E) not enough information



- 14) Which of the following types of compounds will NOT undergo a gas evolution reaction when acid is added? 14) D
- A) carbonates
  - B) bisulfites
  - C) sulfides
  - D) hydroxides
  - E) none of the above
- 15) How many moles of H<sub>2</sub> can be made from complete reaction of 3.0 moles of Al? 15) D
- Given:  $2 \text{ Al} + 6 \text{ HCl} \rightarrow 2 \text{ AlCl}_3 + 3 \text{ H}_2$
- A) 9.0 moles
  - B) 3.0 moles
  - C) 3 moles
  - D) 4.5 moles
  - E) none of the above
- 16) What is the equivalent pressure of 968 mm Hg in units of atm? 16) C
- A) 1.30 atm
  - B) 968 atm
  - C) 1.27 atm
  - D) 0.785 atm
  - E) none of the above
- 17) A 325 mL sample of gas is initially at a pressure of 721 torr and a temperature of 32°C. If this gas is compressed to a volume of 286 mL and the pressure increases to 901 torr, what will be the new temperature of the gas (reported to three significant figures in °C)? 17) A
- A) 62.4°C
  - B) 35.2°C
  - C) 335°C
  - D) 215°C
  - E) none of the above
- $$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$
- 18) A 3.76 g sample of a noble gas is stored in a 2.00 L vessel at 874 torr and 25°C. What is the noble gas? 18) C
- (R = 0.0821 L atm/ mol K)
- A) He
  - B) Ne
  - C) Ar
  - D) Kr
  - E) not enough information
- 19) The vapor pressure of water at 20.0°C is 17.5 mm Hg. If the pressure of a gas collected over water was measured to be 453.0 mm Hg. What is the pressure of the pure gas? 19) D
- A) 0.596 atm
  - B) 0.0230 atm
  - C) 0.619 atm
  - D) 0.573 atm
  - E) none of the above

- 20) Which state of matter has a high density and a definite volume? 20) D  
A) liquids  
B) solids  
C) gases  
D) both solids and liquids  
E) none of the above
- 21) The tendency of a liquid to minimize its surface area is called: 21) A  
A) surface tension.  
B) viscosity.  
C) capillary action.  
D) vaporization.  
E) none of the above
- 22) Increasing the intermolecular forces of a liquid will do which of the following? 22) E  
A) decrease the vapor pressure  
B) decrease the evaporation rate  
C) increase the surface tension  
D) increase the viscosity  
E) all of the above
- 23) The opposite process of freezing is: 23) E  
A) sublimation.  
B) condensation.  
C) evaporation.  
D) boiling.  
E) none of the above
- 24) The amount of heat required to melt one mole of a solid is called the: 24) C  
A) cooling curve.  
B) heat of vaporization.  
C) heat of fusion.  
D) heating curve.  
E) none of the above
- 25) When you make ice cubes: 25) C  
A) the process is referred to scientifically as sublimation.  
B) the heat of vaporization must be removed.  
C) it is an exothermic process.  
D) it is an endothermic process.  
E) none of the above

- 26) How many kilojoules of heat are needed to completely vaporize 42.8 grams of  $C_4H_{10}O$  at its boiling point? 26) A  
Given  $\Delta H_{vap} = 26.5 \text{ kJ/mol}$   
A) 15.3  
B) 9.49  
C) 16.3  
D) 74.12  
E) none of the above
- 27) When sufficient quantity of heat has been added to reach the boiling point of a solution, what happens to any additional heat added? 27) B  
A) Additional heat raises the temperature of the liquid which in turn increases the rate at which boiling occurs. ✗  
B) Additional heat is used to evaporate the liquid as the process is endothermic and requires continued input of energy.  
C) Additional heat lowers the intermolecular forces of the liquid which in turn increases the volatility of the liquid. ✗  
D) Additional heat alters the viscosity and the surface tension of the liquid which raises the vapor pressure and increases the boiling point which is why you must continually heat the solution. ✗  
E) None of the above are correct statements.

**TRUE/FALSE. On the scantron, fill up circle "A" for a true answer and "B" for wrong answer (3 pts each).**

- 28) The reaction of baking soda and vinegar to produce carbon dioxide gas is an example of a precipitation reaction. 28) B
- 29) The formation of a gas is evidence of a chemical reaction while the emission of light is not. 29) B
- 30) Mixing two aqueous solutions will always result in formation of a precipitate. 30) B
- 31) Gas particles act independently of each other. 31) A
- 32) Gases and liquids are compressible, but solids are not. 32) B
- 33) Pressure depends on how many gas particles are in a container. 33) A
- 34) The volume of a gas is independent of the temperature. 34) B
- 35) Intermolecular forces determine if a substance is a solid, liquid or gas at room temperature. 35) A
- 36) Evaporation is decreased by increasing the intermolecular forces. 36) A