

CHM 1311B
MIDTERM 1
Thursday, October 20, 2011
Professor: A. Flynn

First name: _____ Last name: _____

Student number: _____

Seat number: _____

INSTRUCTIONS

Make sure that you have all pages of your midterm.

The midterm is 80 minutes in length.

You may use pen or pencil.

Only faculty-approved calculators are permitted: Texas instruments: TI-30 and TI-34 as well as Casio fx-260 and fx-300.

No other aids are allowed.

There is a periodic table, formulas, conversion factors and constants on the last three pages of the midterm that may be detached.

Total number of points: 70

The points are given as a guide and are subject to minor changes.

GOOD LUCK!!

1. State whether the following properties are physical or chemical: **4 points**

- a. A piece of sliced apple turns brown. chemical ①
- b. A basement floor feels cold to the touch. physical ①
- c. A ruby is red. physical ①
- d. An egg that is boiled in water becomes hard. chemical ①

2. A solution containing 12.0% sodium hydroxide by mass in water has a density of 1.131 g/mL. What volume of this solution, in liters, must be used in an application requiring 2.25 kg of sodium hydroxide? **5 points**

$$V = 2.25 \text{ kg NaOH} \times \frac{1000 \text{ g NaOH}}{1 \text{ kg NaOH}} \times \frac{100 \text{ g sol'n}}{12.0 \text{ g NaOH}} \times \frac{1 \text{ mL}}{1.131 \text{ g}}$$

$$\times \frac{1 \text{ L}}{1000 \text{ mL}}$$

$$= 16.6 \text{ L} \text{ ①}$$

3. A sample of pure carbon weighing 5.91 g was burned in an excess of air. The mass of carbon dioxide obtained (the sole product) was 21.66 g. What mass of oxygen was consumed? **2 points**

$$m_{O_2} = 21.66 \text{ g} - 5.91 \text{ g} \text{ ①}$$

$$= 15.75 \text{ g} \text{ ①}$$

4. Complete the following table: **4 points**

| Name | Atomic number | Number of protons | Number of electrons | Number of neutrons | Mass number |
|------------------|---------------|-------------------|---------------------|--------------------|-------------|
| Calcium | 20 | 20 | 20 | 21 | 41 |
| Carbon | 6 | 6 | 6 | 8 | 14 |
| Potassium cation | 19 | 19 | 18 | 20 | 39 |

① ① ① ①

(Atomic # = # protons)

5. Give the formula or the name of each compound, as appropriate: **4 points**

a. Sodium nitrate NaNO₃

b. KBr Potassium bromide

c. Sulfurous acid H₂SO₃

d. N₂O Dinitrogen monoxide

6. Give an example of an extensive property. **1 point**

Energy Enthalpy

Mass

7. Indicate the oxidation state of each of the underlined atoms: **3 points**

a. CH₄ -4

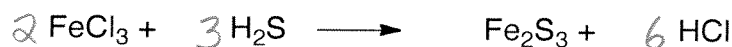
b. S₂O₃²⁻ -2

c. CsO₂ +4

8. The fact that the volume of a fixed amount of gas at a fixed temperature is inversely proportional to the gas pressure is an example of: **1 point**

- a. A hypothesis
- b. A theory
- c. A natural law
- d. An experiment

9. Balance the following equation: **2 points**



10. If $PV/nRT > 1$ for chlorine gas, what two key pieces of information does that tell you? **2 points**

① volume of Cl₂^{molecules} is greater than assumed/predicted by the ideal gas law (i.e., volume of Cl₂ molecules ≠ 0)

② This is a non ideal gas

11. Adenine, a component of nucleic acids, contains C, H and N and has 44.45% C and 3.73% H by mass. Its molecular mass is 135.14 u. What is its molecular formula? Assume 100g of sample

8 points

$$\textcircled{1} n_C = 44.45 \text{ g C} \times \frac{\text{mol}}{12.01 \text{ g}} = 3.701 \text{ mol}$$

$$\textcircled{1} n_H = 3.73 \text{ g H} \times \frac{\text{mol}}{1.01 \text{ g}} = 3.69 \text{ mol}$$

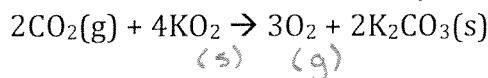
$$\textcircled{1} n_N = \underbrace{(100.00 - 44.45 - 3.73)}_{\textcircled{1} (51.82 \text{ g})} \times \frac{\text{mol}}{14.01 \text{ g}} = 3.699 \text{ mol}$$

① Empirical formula = C₁H₁N₁ or CHN

$$\textcircled{1} \text{ mass} = 12.01 \text{ u} + 1.01 \text{ u} + 14.01 \text{ u} = 27.03 \text{ u} \rightarrow$$

12. The reaction of potassium superoxide, KO₂, is used in life-support systems to replace CO₂(g) in expired air with O₂(g). The balanced chemical equation for the reaction is given below. How many moles of O₂(g) are produced by the reaction of 156 g CO₂(g) with excess KO₂(s)?

3 points



$$n_{\text{O}_2} = 156 \text{ g CO}_2 \times \frac{\textcircled{1} \text{ mol CO}_2}{44.01 \text{ g}} \times \frac{\textcircled{1} 3 \text{ mol O}_2}{2 \text{ mol CO}_2} = 5.32 \text{ mol } \textcircled{1}$$

$$\frac{135.14 \mu}{27.03 \mu} = 5 \quad \text{(Q11 cont)} \quad (1)$$



↑
adenine

15. One method of removing $\text{CO}_2(\text{g})$ from a spacecraft is to allow the CO_2 to react with LiOH . How many liters of $\text{CO}_2(\text{g})$ at 25.9°C and 751 Torr can be removed per kilogram of LiOH consumed?

7 points



- ① Determine n of $\text{CO}_2(\text{g})$ that can be removed

$$n_{\text{CO}_2} = 1.00 \text{ kg LiOH} \times \frac{1000 \text{ g LiOH}}{\text{kg LiOH}} \times \frac{1 \text{ mol LiOH}}{23.95 \text{ g}} \times \frac{1 \text{ mol CO}_2}{2 \text{ mol LiOH}}$$
$$= 20.9 \text{ mol}$$

- ② Determine volume of $\text{CO}_2(\text{g})$

$$P = 751 \text{ Torr} \times \frac{1 \text{ atm}}{760 \text{ Torr}} \text{ (conversion to atm)}$$

$$= 0.988 \text{ atm}$$

$$T = 298.9 \text{ K} \text{ (conversion to K)}$$

$$PV = nRT$$

$$(0.988 \text{ atm})V = 20.9 \text{ mol} (0.0820574) (298.9 \text{ K})$$

$$V = 518.84 \text{ L}$$

$$V = 519 \text{ L} \text{ (1)}$$

16. A 1.397 g sample of thymol, $C_{10}H_{14}O(s)$ (a preservative and a mold and mildew preventative), is burned in a bomb calorimeter assembly. The temperature increase is $11.23^\circ C$ and the heat capacity of the bomb calorimeter (including the water jacket) is $4.68 \text{ kJ}/^\circ C$. What is the heat of combustion of thymol, expressed in kilojoules per mole of thymol? **5 points**



$$\Delta T = 11.23^\circ C$$

$$\begin{aligned} \textcircled{1} n_{\text{thymol}} &= 1.397 \text{ g} \times \frac{\text{mol}}{150.24 \text{ g}} \\ &= 9.298 \times 10^{-3} \text{ mol} \end{aligned}$$

$$\begin{aligned} \textcircled{1} q_{\text{bomb}} &= 11.23^\circ C \times \frac{4.68 \text{ kJ}}{^\circ C} \\ &= 52.6 \text{ kJ} \end{aligned}$$

$$\textcircled{1} q_{\text{rxn}} = -52.6 \text{ kJ}$$

Heat of combustion of thymol:

$$\textcircled{1} = \frac{-52.6 \text{ kJ}}{9.298 \times 10^{-3} \text{ mol}}$$

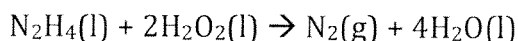
$$\textcircled{1} = -5.65 \times 10^3 \text{ kJ/mol}$$

17. State whether each of the following statements is true or false. Assume that the gases behave ideally. **3 points**

- a. The volume of 1.00 mol of $\text{H}_2(\text{g})$ at 50 K and 1 atm is the same as the volume of 1.00 mol of $\text{Ar}(\text{g})$ at 50 K and 1 atm. T
- b. Under the same conditions of temperature and pressure, the root mean square speed of O_2 molecules is greater than the root mean square speed of H_2 molecules. F
- c. The sign (-/+) for work, w , is negative for an expanding gas. T

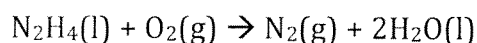
18. Given the reactions and their corresponding ΔH° values below, calculate the ΔH° for the formation of nitrogen gas and liquid water from the reaction of hydrazine, N_2H_4 , with hydrogen peroxide, H_2O_2 . **7 points**

Overall reaction:

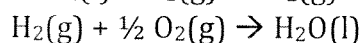


Related reactions:

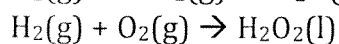
① →



$$\Delta H^\circ = -622.2 \text{ kJ/mol} \quad \checkmark$$



$$\Delta H^\circ = -285.8 \text{ kJ/mol} \quad \times 2 \quad \text{①}$$



$$\Delta H^\circ = -187.8 \text{ kJ/mol} \quad \text{FLIP} + \quad \times 2 \quad \text{①}$$

② →



$$\text{①} \Delta H^\circ = -571.6 \text{ kJ/mol}$$

③ →



$$\text{①} \Delta H^\circ = 375.6 \text{ kJ/mol}$$

Add ① + ② + ③ to get overall rxn

$$\text{Overall } \Delta H^\circ = \left. \begin{array}{r} -622.2 \text{ kJ/mol} \\ -571.6 \text{ kJ/mol} \\ 375.6 \text{ kJ/mol} \end{array} \right\} \text{①}$$

$$\underline{\underline{-818.2 \text{ kJ/mol} \quad \text{①}}}$$