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

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

(1) (1) (1) (1) (1)

$$= 16.6\ \text{L}$$ (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

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

$= 15.75\ \text{g}$ (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 $NaNO_3$

   b. KBr Potassium bromide

   c. Sulfurous acid H_2SO_3

   d. N_2O 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. $\underline{\mathbf{C}}H_4$ -4

   b. $S_2\underline{\mathbf{O}}_3^{2-}$ -2

   c. $\underline{\mathbf{Cs}}O_2$ $+4$

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

$$2\ FeCl_3 + 3\ H_2S \longrightarrow Fe_2S_3 + 6\ HCl$$

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

(1) volume of Cl_2 molecules is greater than assumed/predicted by the ideal gas law (i.e., volume of Cl_2 molecules $\neq 0$)

(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? 8 points

Assume 100g of sample

(1) $n_C = 44.45\,g\,C \times \frac{mol}{12.01\,g}$ (1) $n_H = 3.73\,g\,H \times \frac{mol}{1.01\,g}$

$= 3.701\,mol$ $= 3.69\,mol$

(1) $n_N = (100.00\,g - 44.45\,g - 3.73\,g) \times \frac{mol}{14.01\,g}$

(1) (51.82 g)

$= 3.699\,mol$

(1) Empirical formula = $C_1H_1N_1$ or CHN

(1) mass = 12.01u + 1.01u + 14.01u

= 27.03u →

12. The reaction of potassium superoxide, KO_2, is used in life-support systems to replace $CO_2(g)$ in expired air with $O_2(g)$. The balanced chemical equation for the reaction is given below. How many moles of $O_2(g)$ are produced by the reaction of 156 g $CO_2(g)$ with excess $KO_2(s)$? 3 points

$$2CO_2(g) + 4KO_2(s) \rightarrow 3O_2(g) + 2K_2CO_3(s)$$

$$n_{O_2} = 156\,g\,CO_2 \times \frac{(1)\ mol\,CO_2}{44.01\,g} \times \frac{(1)\ 3\,mol\,O_2}{2\,mol\,CO_2}$$

$= 5.32\,mol$ (1)

Q11 cont

$$\frac{135.14\,u}{27.03\,u} = 5$$ (1)

$CHN \times 5 = C_5H_5N_5$ (1)

↗ adenine

13. Lithopone is a brilliant white pigment used in water-based interior paints. It is a mixture of $BaSO_4$ and ZnS produced by the reaction:

$$BaS(aq) + ZnSO_4(aq) \longrightarrow ZnS(s) + BaSO_4(s)$$

a. How many grams of lithopone should be produced in the reaction of 285 mL of 0.315 M BaS and 315 mL of 0.275 M $ZnSO_4$? 5 points

① convert to moles

① $n_{BaS} = 285\,mL \times \frac{L}{1000\,mL} \times \frac{0.315\,mol}{L}$

$= 0.0898\,mol$

① $n_{ZnSO_4} = 315\,mL \times \frac{L}{1000\,mL} \times \frac{0.275\,mol}{L}$

$= 0.0866\,mol$ } LIMITING REAGENT ①

② MM of lithopone = 330.86 g/mol ①

③ mass of lithopone = $0.0866\,mol \times \frac{330.86\,g}{mol}$

$= 28.7\,g$ ①

b. If 26.0 g of lithopone are produced in the reaction, what is the percent yield of the reaction? 2 points

$\%\ yield = \frac{26.0\,g\ ①}{28.7\,g} \times 100\%$

$= 90.7\%$ ①

14. Complete and balance this half-reaction for a redox reaction that occurs in acidic solution. 3 points

$4H^+ + 3e^- + MnO_4^- \longrightarrow MnO_2 + 2H_2O$

① ① ①

15. One method of removing $CO_2(g)$ from a spacecraft is to allow the CO_2 to react with LiOH. How many liters of $CO_2(g)$ at 25.9 °C and 751 Torr can be removed per kilogram of LiOH consumed? 7 points

$$2\ LiOH(s) + CO_2(g) \longrightarrow Li_2CO_3(s) + H_2O(l)$$

(1) Determine n of $CO_{2(g)}$ that can be removed

$$n_{CO_2} = 1.00\,kg\,LiOH \times \frac{1000\,g\,LiOH}{kg\,LiOH}\,(1) \times \frac{mol\,LiOH}{23.95\,g}\,(1) \times \frac{1\,mol\,CO_2}{2\,mol\,LiOH}\,(1)$$

$$= 20.9\,mol\,(1)$$

(2) Determine volume of $CO_{2(g)}$

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

$$= 0.988\,atm$$

$$T = 298.9\,K\,(1)\ (\text{conversion to K}).$$

$$PV = nRT$$

$$(0.988\,atm)V = 20.9\,mol\,(0.0820574)(298.9\,K)$$

$$V = 518.84\,L$$

$$V = 519\,L \quad (1)$$

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 °C and the heat capacity of the bomb calorimeter (including the water jacket) is 4.68 kJ/°C. What is the heat of combustion of thymol, expressed in kilojoules per mole of thymol? 5 points

$$C_{10}H_{14}O_{(s)} + O_2 \longrightarrow CO_2 + H_2O$$

(not balanced)

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

(1) $n_{thymol} = 1.397\ g \times \frac{mol}{150.24\ g}$

$= 9.298 \times 10^{-3}\ mol$

(1) $q_{bomb} = 11.23\ ^\circ\cancel{C} \times \frac{4.68\ kJ}{^\circ\cancel{C}}$

$= 52.6\ kJ$

(1) $q_{rxn} = -52.6\ kJ$

Heat of combustion of thymol:

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

(1) $= -5.65 \times 10^3\ kJ/mol$

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 $H_2(g)$ at 50 K and 1 atm is the same as the volume of 1.00 mol of Ar(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 $\Delta H°$ values below, calculate the $\Delta H°$ 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:

$$N_2H_4(l) + 2H_2O_2(l) \rightarrow N_2(g) + 4H_2O(l)$$

Related reactions:

(1) → $N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(l)$ $\Delta H° = -622.2$ kJ/mol ✓ (1)

$H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(l)$ $\Delta H° = -285.8$ kJ/mol × 2 (1)

$H_2(g) + O_2(g) \rightarrow H_2O_2(l)$ $\Delta H° = -187.8$ kJ/mol FLIP + × 2 (1) (1)

(2) → $2H_2 + O_2 \rightarrow 2H_2O$ (1) $\Delta H° = -571.6$ kJ/mol

(3) → $2H_2O_2 \rightarrow 2H_2 + 2O_2$ (1) $\Delta H° = 375.6$ kJ/m

Add (1) + (2) + (3) to get overall rxn

Overall $\Delta H°$ = -622.2 kJ/mol
-571.6 kJ/mol
375.6 kJ/mol (1)

-818.2 kJ/mol (1)