

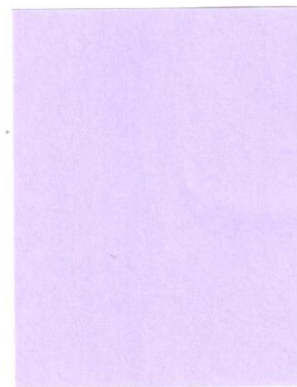
Last name : \_\_\_\_\_ Given name : \_\_\_\_\_

Student number: \_\_\_\_\_

# Chemistry 1311F

## Test 1 V1

### October 15, 2015



1. (5 points) Concentrated nitric acid is 70 % by mass  $\text{HNO}_3(\text{aq})$  and has a density of 1.41 g/ml. What volumes of water and concentrated acid do I need to prepare 500 ml of 3.2 M  $\text{HNO}_3(\text{aq})$ .

Hint: determine the concentration of the concentrated  $\text{HNO}_3(\text{aq})$  in moles/l.

Assume 1L, 1410g of sol<sup>n</sup>

mass  $\text{HNO}_3$  987

$n_{\text{HNO}_3} = 15.66$  moles in 1L.

$$C_1 V_1 = C_2 V_2$$
$$15.66 V_1 = 3.2 \times 500$$
$$V_1 = 102.2 \text{ ml}$$

Volume conc  $\text{HNO}_3$  102.3 ml

$V_{\text{H}_2\text{O}} = 397.8 \text{ ml}$

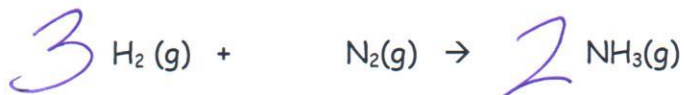
Bonus: Distinguish between an ideal gas and a noble gas.

Ideal: No volume, no intermolecular forces

Noble: Chemically unreactive (gfp 18)

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2. a) (1 point) Hydrogen and nitrogen gas react spontaneously, in a sealed reaction vessel to produce ammonia,  $\text{NH}_3(\text{g})$ . Balance the chemical reaction:



b) (3 points) What is the maximum mass of ammonia that could be produced from 24.0 kg of  $\text{H}_2(\text{g})$  and 84.0 kg of  $\text{N}_2(\text{g})$ ?

$$n_{\text{H}_2} = 11905$$

$$n_{\text{N}_2} = 2998$$

$\text{N}_2$  limiting

$$n_{\text{NH}_3} = 5996 \text{ moles}$$

$$\text{mass NH}_3 = 102.1 \text{ kg}$$

c) (1 point) If only 68 kg of  $\text{NH}_3(\text{g})$  were formed, what is the % yield for the experiment?

$$66.6\%$$

d) (2 points) Determine the volume of the reaction vessel maintained at  $400^\circ\text{C}$  if the initial pressure of reactant gases was 100 bar.

$$n_{\text{H}_2} = 11905$$

$$n_{\text{N}_2} = 2998$$

$$n_{\text{T}} = 14903$$

$$V = 8339 \text{ L}$$

e) (3 points) What is the final pressure in the reaction vessel ( $T = 400^\circ\text{C}$ ) after 68 kg of  $\text{NH}_3(\text{g})$  forms (assuming the formation of  $\text{NH}_3$  is the only reaction that occurs)?

$$n_{\text{NH}_3} = 3933$$

$$n_{\text{H}_2 \text{ used}} = 5989 \quad n_{\text{H}_2 \text{ left}} = 5916$$

$$n_{\text{N}_2 \text{ used}} = 1997 \quad n_{\text{N}_2 \text{ left}} = 1001$$

$$n_{\text{T}} = 10850$$

$$P_{\text{T}} = 73 \text{ bar}$$

Bonus: What is your favourite covalent compound? Why?

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3. You are required to determine if an unknown white powder found in your General Chemistry laboratory locker is heroin ( $C_{21}H_{22}NO_5$ ). A 38.70 mg sample is used in a combustion analysis and 52.69 ml of  $CO_2$  are collected over water at 22 °C (vapour pressure of water at 22°C is 19.84 mm Hg).

a) (3 points) If the atmospheric pressure was 1.057 bar, determine the % composition of C in the sample

70.6874%

b) (1.5 points) In addition, the 38.70 mg sample of the white powder yielded 20.81 mg of water. Determine the % composition of H in the sample.

6.02%

d) (1.5 points) A second sample 55.45 mg was analyzed for its nitrogen content; the sample was heated in concentrated acid to form 2.56 mg  $NH_3$ . Determine the % composition of N in the sample.

3.80%

e) (3 points) What is the empirical formula for the white powder?

$C_{21}H_{22}O_5N$

f) (1 point) Could it be heroin? Explain your answer.

/10

Yes. empirical formula = molecular formula. 3

4. a) (2 points) An electric heater is used to calibrate a constant volume calorimeter and determine the  $C_{\text{cal}}$ . The lab technician found that addition of 19.78 kJ of heat raised the temperature of the calorimeter by 2.52 °C. Determine  $C_{\text{cal}}$ .

$$7.85 \text{ kJ/mol } ^\circ\text{C}$$

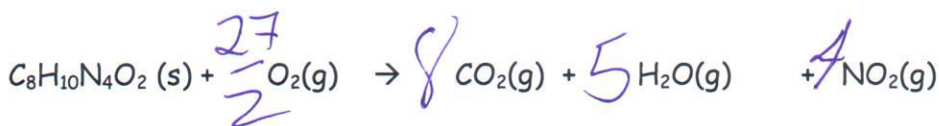
b) (3 points) A 1.35 g sample of caffeine ( $\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$ ) is burned in the same calorimeter and the temperature increases from 24.65 °C to 29.05 °C. Determine the amount of heat released and the molar enthalpy of combustion of caffeine in kJ / mole of caffeine.

$$q_{\text{rxn}} = -34.54 \text{ kJ}$$

$$n_{\text{caff.}} = 6.95 \times 10^{-3}$$

$$\Delta_{\text{rxn}} H = -4969 \text{ kJ}$$

c) (1 point) Balance the combustion reaction that occurred in the calorimeter:



d) (3 points) Given the data in the table below and your answer in part b above, determine the heat of formation of caffeine,  $\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2 (\text{s})$

|              | $\text{CO}_2 (\text{g})$ | $\text{H}_2\text{O} (\text{g})$ | $\text{NO}_2 (\text{g})$ |
|--------------|--------------------------|---------------------------------|--------------------------|
| $\Delta_f H$ | -394 kJ/mol              | -242 kJ                         | 33                       |

$$\Delta_{\text{rxn}} H = 8 \Delta H_{\text{CO}_2} + 5 \Delta H_{\text{H}_2\text{O}} + 4 \Delta H_{\text{NO}_2} - \frac{27}{2} \Delta H_{\text{O}_2} - \Delta H_{\text{caff.}}$$

$$-4969 = 8(-394) + 5(-242) + 4(33) - \Delta H_{\text{caff.}}$$

$$-4969 = 4230 + (\Delta H_{\text{caff.}})$$

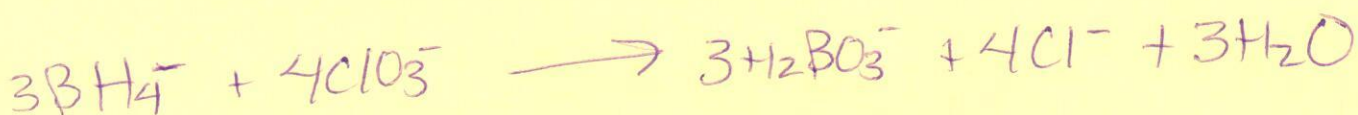
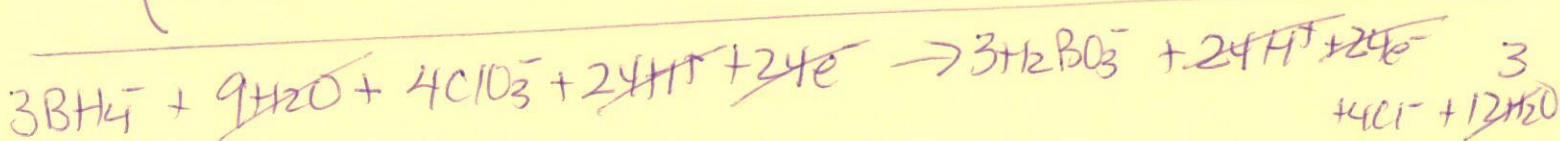
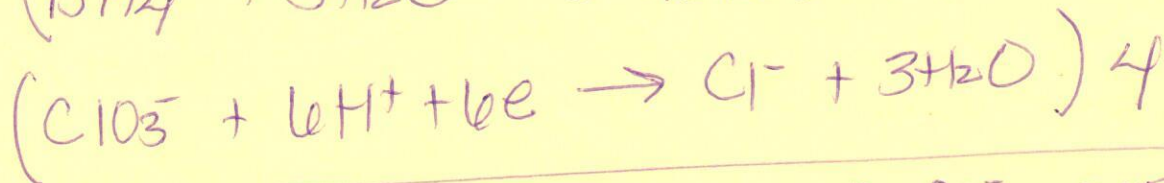
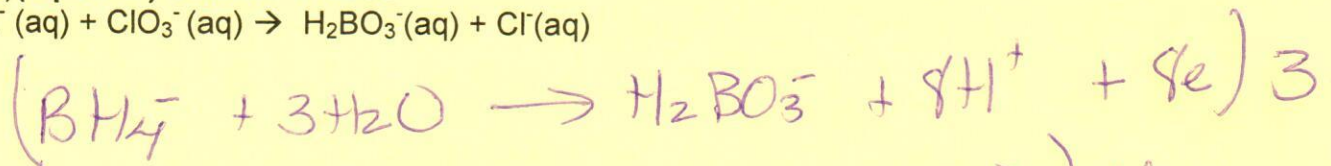
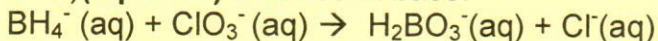
$$\Delta_f H_{\text{caff.}} = 739 \text{ kJ/mol}$$

e) (1 point) Under what experimental conditions is  $\Delta H$  the same as the heat of the reaction?

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Const. P.

5. a) (3 points) Balance in base:



b) (1 point) Identify the oxidation state of:

N in  $\text{KNO}_2$       +3

O in  $\text{KO}_2$        $-\frac{1}{2}$

6. a) (1 points) An element has 3 naturally occurring isotopes:  $^{24}\text{X}$  (isotopic mass 23.9850 u, natural abundance 78.99 %),  $^{25}\text{X}$  (isotopic mass 24.9858 u, natural abundance 10.00 %),  $^{26}\text{X}$  (isotopic mass 25.9826 u, natural abundance 11.01 %). Calculate the atomic mass of this element.

24.3050 u

b) (1 point) How many neutrons, protons and electrons are present in an +2 ion of this element having mass number 25 ?

It is Mg:       $^{25}_{12}\text{Mg}$

p = 12  
n = 13  
e = 10

| Page  | Maximum | Score |
|-------|---------|-------|
| 1     | 4       |       |
| 2     | 10      |       |
| 3     | 10      |       |
| 4     | 10      |       |
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