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Chemistry 1154 Fall 2022 Test 2

Thursday, October 27, 2022 — Time: 1 hour 50 minutes

Name: ANSWERS — Student #: ____________________

*This test consists of **eight** pages of questions, the formula sheet, and a periodic table. Please ensure that you have a complete test and, if you do not, obtain one from me **immediately**. There are **30** marks available. Good luck!*

1) **[3 marks]** How many grams of 80.0-percent pure $AgNO_3$ (169.9 g/mol) are necessary to prepare 1075.4 mg of Ag_2CO_3 (275.744 g/mol) if the reaction

$$2AgNO_3(aq) + Na_2CO_3(aq) \longrightarrow 2NaNO_3(aq) + Ag_2CO_3(s)$$

proceeds with a 62.5 percent yield?

$$1075.4 \text{ mg} \times \frac{100 \text{ theo}}{62.5 \text{ act}} = 1720.64 \text{ mg actual}$$

$$1720.64 \text{ mg } Ag_2CO_3 \times \frac{1 \text{ mol}}{275.744 \text{ g}} \times \frac{2AgNO_3}{1Ag_2CO_3} \times \frac{169.9 \text{ g}}{\text{mol}} =$$

$2120.34\ldots$ mg $AgNO_3$

$$2120.34\ldots \text{ mg } AgNO_3 \times \frac{100 \text{g impure}}{80 \; AgNO_3} = 2650.43\ldots \text{ mg}$$

$= \boxed{2.6504\ldots \text{ g}}$

2) **[6 marks]** If 25.0 mL of 0.15 M $Ca(NO_3)_2$ are mixed with 75.0 mL of 0.050 M Na_3PO_4:

$$3Ca(NO_3)_2(aq) + 2Na_3PO_4(aq) \longrightarrow Ca_3(PO_4)_2(s) + 6NaNO_3(aq)$$

a) Identify the limiting reagent.

LR

$$25\,mL \times \frac{0.15\,moles\,Ca(NO_3)_2}{L} \times \frac{1\,rxn}{3\,Ca(NO_3)_2} = 1.25\,\frac{mmol}{rxn}$$

$$75\,mL \times \frac{0.05\,moles\,Na_3PO_4}{L} \times \frac{1\,rxn}{2\,Na_3PO_4} = 1.875\,\frac{mmol}{rxn}$$

b) What should be the concentration of the $NaNO_3$ after reaction?

$$\frac{25\,mL \times \frac{0.15\,moles\,Ca(NO_3)_2}{L} \times \frac{6\,NaNO_3}{3\,Ca(NO_3)_2}}{100\,mL} = \boxed{0.075\,M}$$

c) What should be the concentration of the excess reagent after reaction?

$$\frac{75\,mL \times \frac{0.05\,moles\,Na_3PO_4}{L} - 25\,mL \times \frac{0.15\,moles\,Ca(NO_3)_2}{L} \times \frac{2\,Na_3PO_4}{3\,Ca(NO_3)_2}}{100\,mL}$$

$$= \boxed{0.0125\,M\,Na_3PO_4}$$

3) **[2 marks]** Calculate the density of SF_6 (146.053 g/mol) at 100 torr pressure and -5.0°C

$$D = \frac{MM \times P}{R \times T} = \frac{146.053 \times 100}{62.3635... \times 268.15}$$

$$= \boxed{0.873 \frac{g}{L}}$$

4) **[4 marks]** The molar mass of magnesium lab was carried out exactly as you'll do it in the lab, with the exception that instead of water (with a density of 1.00 g/cm^3), a mystery fluid was used. Your job is to use the data given to determine the density of the mystery fluid. You will also need to know that the density of mercury is 13.6 g/cm^3 and that, when the data was analyzed, the molar mass of Mg was determined to be 24.6 g/mol (instead of 24.3 g/mol). The reaction between Mg and HCl is:

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2(g)$$

Give your density in g/cm^3.

Data (units)	value
Mass Mg (mg)	52.3
$T_{sol'n}$ (°C)	21.4
P_{atm} (torr)	761.2
VP_{fluid} (torr)	20.3
h (mm)	141
V_{gas} (mL)	53.3

$52.3\ mg \times \frac{1\ mol}{24.6\ g} \times \frac{1\ H_2}{1\ Mg} = 2.126016...\ mmol\ H_2$

$P_{H_2} = 761.2 - 20.3 - 141 \times \frac{D}{13.6}$

$= 740.9 - 10.36...D$

$n_{H_2} = \frac{(740.9 - 10.36...D)(53.3)}{(62.36359822)(294.55)}$

$= (0.0029...)(740.9 - 10.36...D)$

$= 2.126016...$

$732.7056909 = 740.9 - 10.36...D$

$10.36D = 8.194309055$

$D = 0.790373072\ \frac{g}{cm^3}$

5) **[4 marks]** The following apparatus was assembled:

Bulb 1:
Chemical: $NH_3(g)$
Pressure: 2 bar
Volume: 7 litres

Bulb 2:
Chemical: $O_2(g)$
Pressure: 5 bar
Volume: 3 litres

The bulbs were connected by a valve, and both bulbs were maintained at a temperature of 929.57°C at all times. When the valves were opened, the following reaction occurred:

$$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$$

Calculate the mole fractions of all species after reaction.

$n_{NH_3} = \frac{14}{RT}$; $n_{O_2} = \frac{15}{RT}$

LR:

$\frac{14}{RT}$ moles $NH_3 \times \frac{1 \text{ rxn}}{4 NH_3} = \frac{3.5}{RT}$ moles rxn

$\frac{15}{RT}$ moles $O_2 \times \frac{1 \text{ rxn}}{5 O_2} = \frac{3}{RT}$ moles rxn (LR)

NO: $\frac{15}{RT}$ moles $O_2 \times \frac{4 NO}{5 O_2} = \frac{12}{RT}$ moles NO

H_2O $\frac{15}{RT}$ moles $O_2 \times \frac{6 H_2O}{5 O_2} = \frac{18}{RT}$ moles H_2O

NH_3 L.O.: $\frac{14}{RT}$ moles $NH_3 - \frac{15}{RT}$ moles $O_2 \times \frac{4 NH_3}{5 O_2} = \frac{2}{RT}$

Total moles = $\frac{12}{RT} + \frac{18}{RT} + \frac{2}{RT} = \frac{32}{RT}$

$X_{NH_3} = \frac{\frac{2}{RT}}{\frac{32}{RT}} = \frac{1}{16}$

$X_{NO} = \frac{\frac{12}{RT}}{\frac{32}{RT}} = \frac{3}{8}$

$X_{H_2O} = \frac{\frac{18}{RT}}{\frac{32}{RT}} = \frac{9}{16}$

6) **[3 marks]** For the reaction:

$$H_2(g) + I_2(s) \rightleftharpoons 2HI(g)$$

Which of the following changes should drive the reaction forward (that is, create more products), and which should change the value of K_p for the reaction? Circle your choice in each case. If the change does not affect K_p or drive the reaction forward, circle "Neither."

Adding some $H_2(g)$	Forward	K_p	Neither
Decreasing the volume of the reaction container	Forward	K_p	Neither
Adding some NaOH (reacts with HI)	Forward	K_p	Neither

7) **[8 marks]** Given the equilibrium:

$2C(s) + 3H_2(g) \rightleftharpoons C_2H_6(g) \quad \Delta H° = -84\text{ kJ and } K_p = 19.9 \text{ @ } 150°C$

a) K_p for the reaction

$2C_2H_6(g) \rightleftharpoons 4C(s) + 6H_2(g)$

at 150°C would be:

i) -396.01
ii) -39.8
iii) 0.00253
iv) 0.0251

b) K_c for the reaction

$2C(s) + 3H_2(g) \rightleftharpoons C_2H_6(g) \quad \Delta H° = -84\text{ kJ and } K_p = 19.9 \text{ @ } 150°C$

at 150°C would be:

$(19.9)(RT)^2$

i) 2.46×10^4
ii) 2.46×10^8
iii) 3.05×10^7
iv) 3.05×10^{15}

$K_p = K_c(RT)^{-2}$

$K_c = K_p(RT)^2$

c) K_p for the reaction

$2C(s) + 3H_2(g) \rightleftharpoons C_2H_6(g) \quad \Delta H° = -84\text{ kJ and } K_p = 19.9 \text{ @ } 150°C$

at 175°C would be:

$\ln\left(\frac{K}{19.9}\right) = \frac{-84000}{8.31} \times \left(\frac{448.15 - 423.15}{448.15 \times 423.15}\right)$

i) 2.9×10^{-57}
ii) 0.00132
iii) 5.25
iv) 19.9

$\Rightarrow K =$

d) Given the additional reaction

$2C(s) + 2H_2(g) \rightleftharpoons C_2H_4(g)$ $K_p = 5.63 \times 10^{-10}$ @150°C

then K_p for the reaction

$C_2H_4(g) + H_2(g) \rightleftharpoons C_2H_6(g)$

at 150°C would be

i) -1.12×10^{-8}
ii) 1.12×10^{-8}
iii) 19.9
iv) 3.53×10^{10}

$2C + 2H_2 \rightleftharpoons C_2H_4$ $K_p = 5.63 \times 10^{-10}$

$2C + 3H_2 \rightleftharpoons C_2H_6$ $K_p = 19.9$