

Chemistry 1105 Spring 2024 Test 3

Thursday, March 28, 2024

Time: 1 hour 50 minutes

Name: ANSWERS

Student #: _____

This test consists of **eight** pages of questions, a page of useful constants and conversions, and a periodic table. Please ensure that you have a complete test and, if you do not, obtain one from me **immediately**. There are **35** marks available. Good luck!

- 1) [3 marks] At 100 torr pressure and 90.46°C, the density of a gas of formula H_2O_n is 0.150 g/L. What is the number, n ?

$$MM = \frac{(0.15)(62.36359822)(363.61)}{100} = 34.014 \dots \frac{g}{mol}$$

$$2(1.0079) + n(15.999) = 34.014 \dots \Rightarrow \boxed{n=2}$$

- 2) [4 marks] A mixture of two gases (A and B) had a total pressure of 60 atm. There were three moles of gas A, and the mole fraction of gas B was found to be 0.75.

- a) How many moles of gas B were in the mixture?

$$X_A = 0.25$$

$$\frac{3}{n_{\text{Tot}}}$$

$$= 0.25 \Rightarrow n_{\text{Tot}} = 12, \text{ so } \boxed{n_B = 9}$$

- b) What were the partial pressures of each gas?

$$P_A = 0.25(60) = 15 \text{ atm}$$

$$P_B = 0.75(60) = 45 \text{ atm}$$

- 3) [3 marks] According to Apple, the iPhone 15 Pro Max can be submerged in 6 metres of water for up to half an hour. If the density of water is 0.9984 g/cm^3 , how many bars of pressure is exerted by water at this depth?

$$P = D \cdot g \cdot h = 58745.75616 \text{ Pa}$$

Diagram showing the derivation of the pressure formula $P = D \cdot g \cdot h$. Arrows point from the variables to their values: D points to $9.80665 \frac{\text{m}}{\text{s}^2}$, g points to $9.80665 \frac{\text{m}}{\text{s}^2}$, and h points to 6 m .

$$58745 \text{ Pa} \times \frac{1 \text{ bar}}{100,000 \text{ Pa}} = 0.587 \text{ bar}$$

$$0.9984 \frac{\text{g}}{\text{cm}^3} \times \frac{1 \text{ kg}}{1000 \text{ g}} \times \left(\frac{100 \text{ cm}}{1 \text{ m}} \right)^3 = 998.4 \frac{\text{kg}}{\text{m}^3}$$

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

Flask 1:

Volume: 8 L

Filled with: HCN

At a pressure of: 5 atm

Flask 2:

Volume: 12 L

Filled with: H₂

At a pressure of 7 atm

Both flasks were kept at a temperature of 336.18°C before, during, and after reaction.

When the valve was opened, the following reaction occurred:



Calculate the partial pressures of all species **after** reaction.

$$n_{\text{HCN}} = \frac{5 \cdot 8}{RT} = \frac{40}{RT} \quad n_{\text{H}_2} = \frac{7 \cdot 12}{RT} = \frac{84}{RT}$$

LR check:

$$\frac{40 \text{ moles HCN}}{RT} \times \frac{1 \text{ rxn}}{1 \text{ HCN}} = \frac{40 \text{ moles rxn}}{RT}$$

$$\frac{84 \text{ moles H}_2}{RT} \times \frac{1 \text{ rxn}}{3 \text{ H}_2} = \frac{28 \text{ moles rxn}}{RT}$$

LR

$$\text{HCN L.O.} = \frac{40 \text{ moles HCN}}{RT} - \frac{84 \text{ moles H}_2}{RT} \times \frac{1 \text{ HCN}}{3 \text{ H}_2} = \frac{12}{RT}$$

$$\text{CH}_4 \text{ (and NH}_3\text{) made: } \frac{84 \text{ moles H}_2}{RT} \times \frac{1 \text{ CH}_4}{3 \text{ H}_2} = \frac{28 \text{ moles CH}_4}{RT}$$

$$P_{\text{HCN}} = \frac{\frac{12}{RT} \times RT}{20} = 0.6 \text{ atm} \quad P_{\text{NH}_3} = P_{\text{CH}_4} = \frac{\frac{28}{RT} \times RT}{20} = 1.4 \text{ atm}$$

$$P_{\text{H}_2} = 0$$

5) [4 marks] A 3-mole piece of iron ($\bar{C} = 25.07 \frac{\text{J}}{\text{mol}\cdot^\circ\text{C}}$) at 89.35°C was placed into 200 g of water ($S = 4.184 \frac{\text{J}}{\text{g}\cdot^\circ\text{C}}$) at 15°C . The water was contained in a cup with $C = 20 \frac{\text{J}}{^\circ\text{C}}$. What was the final temperature of the water?

$$q_{\text{Fe}} = 3 \text{ moles} \times 25.07 \frac{\text{J}}{\text{mol}\cdot^\circ\text{C}} \times (T - 89.35)$$

$$+ q_{\text{H}_2\text{O}} = 200 \text{ g} \times 4.184 \frac{\text{J}}{\text{g}\cdot^\circ\text{C}} \times (T - 15)$$

$$+ q_{\text{cup}} = 20 \frac{\text{J}}{^\circ\text{C}} (T - 15)$$

$$0 \text{ J}$$

$$75.21(T - 89.35) + 836.8(T - 15) + 20(T - 15) = 0$$

$$75.21T - 6720.0135 + 836.8T - 12552 + 20T - 300 = 0$$

$$932.01T - 19572.0135 = 0$$

$$\Rightarrow T = 20.99978917$$

$$\approx 21^\circ\text{C}$$

- 6) [4 marks] A 760.9-mg piece of $\text{Ca}(\text{OH})_2$ (74.09 g/mol) was put into 100.0 mL of 0.300 M HCl (1.00 g/mL, $4.184 \frac{\text{J}}{\text{g}\cdot^\circ\text{C}}$) at 22.85°C :



The temperature of the solution increased to 26.65°C . Calculate the molar enthalpy of the reaction.

$$q_{\text{HCl}} = (100 \text{ mL} \times 1.00 \frac{\text{g}}{\text{mL}} + 0.7609 \text{ g}) \times 4.184 \frac{\text{J}}{\text{g}\cdot^\circ\text{C}} \times (26.65 - 22.85)$$

$$\approx 1602 \dots \text{ J}$$

$$+ q_{\text{rxn}} = -1602 \dots \text{ J}$$

$$0 \text{ J}$$

LR check:

$$0.7609 \text{ g Ca}(\text{OH})_2 \times \frac{1 \text{ mol}}{74.09 \text{ g}} \times \frac{1 \text{ rxn}}{1 \text{ Ca}(\text{OH})_2} = 0.010 \dots \text{ mol rxn}$$

$$100 \times 10^{-3} \text{ L} \times \frac{0.3 \text{ mol HCl}}{1 \text{ L}} \times \frac{1 \text{ rxn}}{2 \text{ HCl}} = 0.015 \text{ mol rxn}$$

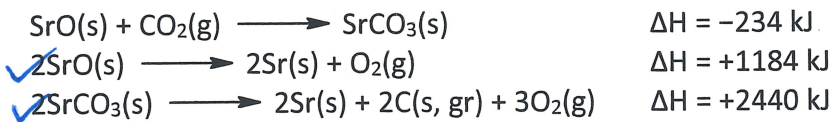
$$\therefore 0.010 \dots \text{ mol rxn} = -1602 \dots \text{ J}$$

or

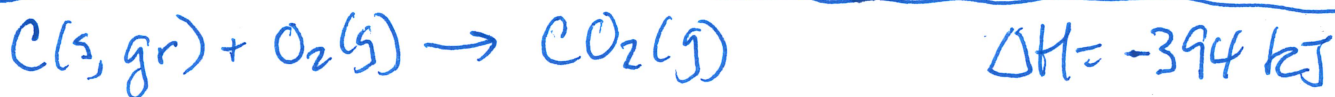
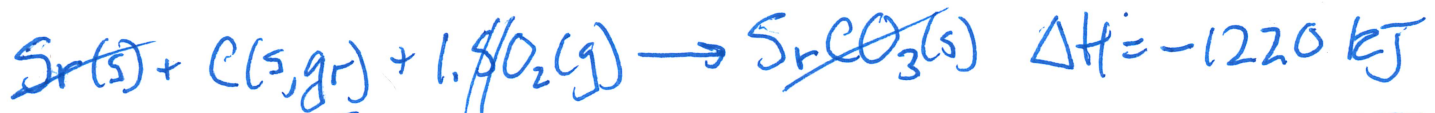
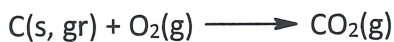
$$1 \text{ mol rxn} = -155990.9206 \dots \text{ J}$$

$$(\approx -156 \text{ kJ})$$

7) [3 marks] Given the following reactions:



Find ΔH for the following reaction:



8) [1 mark] What is the molar enthalpy of formation of SrO(s)?

$$-592 \text{ kJ}$$

9) [4 marks] Given the reaction:



How many kJ of heat would be released by the reaction of 87.62 grams of Sr with 31.998 grams of oxygen and 12.011 grams of C(s, gr)?

LR check:

$$87.62 \text{ g Sr} \times \frac{1 \text{ mol}}{87.62 \text{ g}} \times \frac{1 \text{ rxn}}{2 \text{ Sr}} = 0.5 \text{ moles rxn}$$

$$31.998 \text{ g O}_2 \times \frac{1 \text{ mol}}{31.998 \text{ g}} \times \frac{1 \text{ rxn}}{3 \text{ O}_2} = 0.3 \text{ mol rxn}$$

$$12.011 \text{ g C} \times \frac{1 \text{ mol}}{12.011 \text{ g}} \times \frac{1 \text{ rxn}}{2 \text{ C}} = 0.5 \text{ moles rxn}$$

$$0.3 \text{ moles rxn} \times \frac{-2440 \text{ kJ}}{1 \text{ mole rxn}} = -813.3 \text{ kJ}$$

So 813.3 kJ of heat would be released.

10) [4 marks] Given the following equilibrium:



Predict the effect that each of the changes given below would have on the value of K and on the moles of Cl_2 present in a fresh system initially at equilibrium. Your choices are Increase from the starting value, Decrease from the starting value, or Not Change from the starting value. You may assume that, unless explicitly stated otherwise, the changes were carried out at constant temperature.

	Effect on:					
	K			Cl ₂		
Adding some H ₂	I	D	NC	I	D	NC
Cooling the reaction mixture	I	D	NC	I	D	NC
compressing the reaction mixture	I	D	NC	I	D	NC
Adding a non-reactive gas	I	D	NC	I	D	NC

11) [1 mark] Write a reaction for which the equilibrium expression is $K = [\text{O}_2]$.

There are many possibilities. one
is $\text{O}_2(\text{l}) \rightleftharpoons \text{O}_2(\text{g})$