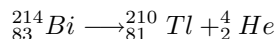


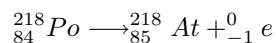
## Solutions to Exam # 3

### Chemistry 101 Fall 2003

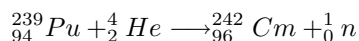
1. (4 pts) Bi-214 is an  $\alpha$  (alpha) emitter. Write a nuclear equation describing the reaction.



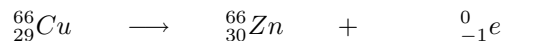
2. (4 pts) Po-218 undergoes  $\beta$  (beta) decay. Write a nuclear equation describing the reaction.



3. (4 pts) Write an equation for a nuclear reaction in which Pu-239 is bombarded with an alpha particle to produce another nucleus and one neutron ( ${}_0^1n$ ).



4. (4 pts) Complete the following nuclear equation:

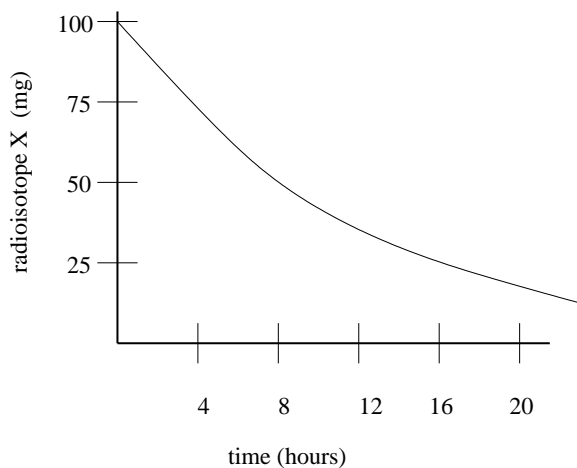


5. (4 pts) Suppose that the radioactivity from Rn-222 in your basement was measured as 0.64 picoCuries. If no additional radon entered your basement, how much time would have to pass before the radiation level fell to 0.02 picoCuries? The half-life of Rn-222 is 3.8 days.

$$0.64 \text{ pCi} \xrightarrow{1 \text{ h.l.}} 0.32 \text{ pCi} \xrightarrow{1 \text{ h.l.}} 0.16 \text{ pCi} \xrightarrow{1 \text{ h.l.}} 0.08 \text{ pCi} \xrightarrow{1 \text{ h.l.}} 0.04 \text{ pCi} \xrightarrow{1 \text{ h.l.}} 0.02 \text{ pCi}$$

*A total of 5 half-lives, so the total time is  $5 \times 3.8 \text{ days} = 19 \text{ days}$ .*

6. (4 pts) Using what you know about half-lives and the diagram below, determine the half-life of radioisotope X. The diagram below shows the decay curve of radioisotope X for an original sample of 100 mg.



*There were 100 mg at time 0, and 50 mg at time 6 hrs, so the half life is 6 hrs. Note that another 6 hrs (12 total) the amount has decreased to 25 mg, half of 50.*

7. (2 pts) (a) Name any one of the four main natural sources of background radiation a person experiences on earth. (b) Name any one of the person-made sources of radiation a person experiences on earth. (clearly label part a and b)

*radon, cosmic, internal, rocks and soil.*

8. (2 pts) Write a sentence which describes the process of nuclear fission.

*A nucleus is bombarded with a neutron and splits into 2 more smaller nuclei (and possibly additional particles like neutrons) and releases a large amount of energy.*

9. (4 pts) Calculate the mass/mass percent ( % m/m ) for the solute in a solution of 20 g KCl in 120 g of solution.

$$\frac{20 \text{ g}}{120 \text{ g}} \times 100\% = 17\%$$

10. (4 pts) Calculate the amount of solute (in g) needed to prepare 500 mL of a 5.0% (m/v) NaCl solution.

$$500 \text{ ml} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{5 \text{ g}}{100 \text{ ml}} = 25 \text{ g}$$

11. (4 pts) Calculate the molarity of a solution prepared by dissolving 0.12 moles of  $\text{K}_2\text{SO}_4$  in water and diluting to a total volume of 2.500 L.

$$\frac{0.12 \text{ moles}}{2.5 \text{ L}} = 0.048 \text{ M}$$

12. (4 pts) Calculate the molarity of a solution prepared by dissolving 76.3 grams of  $\text{KNO}_3$  in water and diluting to a total volume of 2.00 L.

$$\text{molar mass } \text{KNO}_3 = 101.11 \text{ g}$$

$$76.3 \text{ g} \times \frac{1 \text{ mole}}{101.11 \text{ g}} = 0.755 \text{ moles}$$

$$\frac{0.755 \text{ moles}}{2.00 \text{ L}} = 0.377 \text{ M}$$

13. (4 pts) Calculate the number of moles of  $\text{FeCl}_3$  in 400 mL of a 0.50 M solution of  $\text{FeCl}_3$ .

$$\frac{400 \text{ mL}}{1000 \text{ mL}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.50 \text{ moles}}{\text{L}} = 0.2 \text{ moles}$$

14. (4 pts) Suppose 0.325 moles of NaCl are needed for a reaction. If 0.150 M NaCl is available, how many milliliters of the solution will we have to add to our reaction mixture to add the correct number of moles?

$$\frac{0.325 \text{ moles}}{0.150 \text{ mol}} \times \frac{\text{L}}{\text{mol}} = 2.17 \text{ L} = 2170 \text{ mL}$$

15. (4 pts) What is the  $\text{H}_3\text{O}^+$  concentration of a solution with pH = 4.9?

$$[\text{H}_3\text{O}^+] = 10^{-\text{pH}} = 10^{-4.9} = 1.3 \times 10^{-5}$$

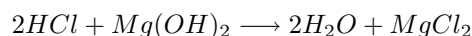
16. (4 pts) What is the pH of a solution in which the concentration of  $\text{H}_3\text{O}^+$  is  $8.2 \times 10^{-8} \text{ M}$ ?

$$\text{pH} = -\log [\text{H}_3\text{O}^+] = -\log 8.2 \times 10^{-8} = 7.09$$

17. (4 pts) Consider an aqueous solution an  $\text{H}_3\text{O}^+$  concentration of  $9.2 \times 10^{-3} \text{ M}$ . Calculate the  $\text{OH}^-$  concentration

$$[\text{OH}^-] = \frac{1 \times 10^{-14}}{9.2 \times 10^{-3}} = 1.1 \times 10^{-12} \text{ M}$$

18. (4 pts) Write the balanced chemical equation for the reaction of magnesium hydroxide  $\text{Mg}(\text{OH})_2$  with hydrochloric acid ( $\text{HCl}$ ). (hint: this is a neutralization reaction)



19. (4 pts) A 7.1 L sample of gas at 200 K is warmed to 325 K. What is the new volume of the gas if the pressure stays constant?

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$V_2 = \frac{V_1 T_2}{T_1} = \frac{(7.1 \text{ L})(325 \text{ K})}{(200 \text{ K})} = 11.5 \text{ L}$$

20. (4 pts) If 48 grams of  $\text{O}_2$  occupies 36.7 L at  $25^\circ\text{C}$  and 1 atm, how many grams of argon (Ar) are in 15.0 L at the same T and p?

$$40 \text{ g} \times \frac{1 \text{ mole}}{32.00 \text{ g}} = 1.5 \text{ moles O}_2$$

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

$$n_2 = \frac{V_2 n_1}{V_1} = \frac{(15.0 \text{ L})(1.5 \text{ moles})}{36.7 \text{ L}} = 0.613 \text{ moles}$$

$$0.613 \text{ moles} \times \frac{40.0 \text{ g}}{\text{mol}} = 24.5 \text{ g}$$

21. (4 pts) A 254 ml gas sample at a pressure of 5.0 atm is enclosed in a container with a movable piston. The piston is moved such that the volume increases to 2.00 L. What is the new pressure of the gas? (be careful with units).

$$P_1 V_1 = P_2 V_2$$

$$P_2 = \frac{P_1 V_1}{V_2} = \frac{(5 \text{ atm})(0.254 \text{ L})}{2.00 \text{ L}} = 0.64 \text{ atm}$$

22. (4 pts) What is the pressure of a sample of 20.0 g of helium (He) in a 16.0 L container at a temperature of  $25^\circ\text{C}$ ?

$$20.0 \text{ g} \times \frac{1 \text{ mol}}{4.00 \text{ g}} = 5.0 \text{ moles}$$

$$P = \frac{nRT}{V} = \frac{(5.0 \text{ mole})(0.08206 \frac{\text{L atm}}{\text{mol K}})(298 \text{ K})}{16.0 \text{ L}} = 7.5 \text{ atm}$$

23. (4 pts) A sample of air in an air-tight container with volume of 6.2 L at a temperature of 20°C has a pressure of 1.00 atm. If the container is heated to 30°C and the container is enlarged to a volume of 10.0 L (without allowing any air in or out, what is the final pressure of the gas?)

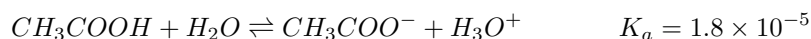
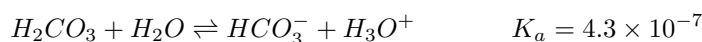
$$PV = nRT$$

$$n = \frac{PV}{RT} = \frac{(1.00 \text{ atm})(6.2 \text{ L})}{(0.08206 \frac{\text{L atm}}{\text{mol K}})(293 \text{ K})} = 0.256 \text{ moles}$$

The moles are constant because no gas gets in or out. So for the final state:

$$P = \frac{nRT}{V} = \frac{(0.256 \text{ mole})(0.08206 \frac{\text{L atm}}{\text{mol K}})(303 \text{ K})}{10.0 \text{ L}} = 0.64 \text{ atm}$$

24. (4 pts) Consider the following acids and their dissociation constants:

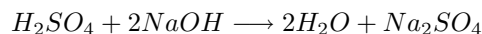


- (a) Which is the stronger acid,  $H_2CO_3$  or  $CH_3COOH$  and why?  *$CH_3COOH$  because of its higher  $K_a$ .*  
 (b) Which acid has the stronger conjugate base?  *$H_2CO_3$  - weaker acids have stronger conjugate bases.*  
 (c) What is the pH of a buffer solution prepared from 0.20 M  $CH_3COOH$  and 0.20 M  $CH_3COO^-$ ?

$$[H_3O^+] = \frac{K_a[CH_3COOH]}{[CH_3COO^-]} = \frac{(1.8 \times 10^{-5})(0.20 \text{ M})}{0.20 \text{ M}} = 1.8 \times 10^{-5}$$

$$pH = -\log 1.8 \times 10^{-5} = 4.74$$

25. (8 pts) The reaction for the neutralization of sulfuric acid ( $H_2SO_4$ ) with NaOH is below:



A 15.0 mL sample of  $H_2SO_4$  is titrated with NaOH. The titration takes 21.5 mL of an NaOH solution which has been standardized to 0.118 M.

- (a) How many moles of NaOH were used for the titration?

$$0.0215 \text{ L} \times \frac{0.118 \text{ mol}}{\text{L}} = 0.002537 \text{ moles NaOH}$$

- (b) From the titration data, how many moles of  $H_2SO_4$  were in the sample?

$$0.002537 \text{ moles NaOH} \times \frac{1 \text{ mole } H_2SO_4}{2 \text{ moles NaOH}} = 0.001268 \text{ moles } H_2SO_4$$

- (c) What was the concentration of the  $H_2SO_4$  in the original sample?

$$\frac{0.001268 \text{ moles}}{0.015 \text{ L}} = 0.0846 \text{ M}$$