

### Spring Examination Study Questions

- (Chapter 6/Heat Changes) A calorimeter containing water is used to measure the heat produced by a chemical reaction. If the water absorbs 58.5 kJ when the temperature is raised from 21.2°C to 77.2°C, how much water was in the calorimeter? (The specific heat of water is 4.18 J/g °C.)
- (Chapter 6/Heat Changes) For the reaction between solid iron and water to form iron(III) oxide and hydrogen gas,
  - write a balanced chemical equation.
  - use the appropriate table to calculate  $\Delta H$  for this reaction.
  - determine whether this reaction is endothermic or exothermic.
- (Chapter 5/Gases) A sample of gas occupies a volume of 5.60 liters at STP.
  - What is the pressure of this sample when it is allowed to expand to 18.0 liters at 78°C?
  - How many moles of gas are in the sample?
  - If the sample contains 7.50 grams of gas, what is the molar mass of this gas?
  - The above gas is an alkane. Give its formula, name the alkane, and draw its structure.
- (Chapter 5/Gases) For the reaction between solid iron and water to form iron(III) oxide and hydrogen gas,
  - write a balanced chemical equation.
  - How many liters of hydrogen gas are produced from 29.8 grams of iron at 1.60 atmospheres and 117°C?
  - What is the density of hydrogen gas in (b)?
- (Chapter 11/Solutions) You may use the equation below to solve the following problems:
$$\Delta T_f = -1.86^\circ\text{C} \times \text{moles solute particles/kg water}$$
  - What is the freezing point of a solution containing 117 g NaCl in 500 g of water?
  - How many moles of a nonelectrolyte in 50 g of water are required for a solution to have a freezing point of  $-2.79^\circ\text{C}$ ?
- (Chapter 11/Solutions)
  - How many g of  $\text{NaNO}_3$  are needed to make 157 ml of a 3.00 M  $\text{NaNO}_3$  solution?
  - Describe how you would make the solution in (a).
  - What is the concentration of  $\text{NaNO}_3$  in a solution prepared by diluting 240 ml of 0.500 M  $\text{NaNO}_3$  to 2.00 liters?
  - The density of a 26.0% solution of  $\text{NaNO}_3$  is 1.19 g/ml. What is the molarity of the 26.0% solution?
- (Chapter 12/Reaction Rate) Explain how and why each of the following affect reaction rate:
  - concentration of reactants
  - surface area of reactants
  - temperature
  - a catalyst

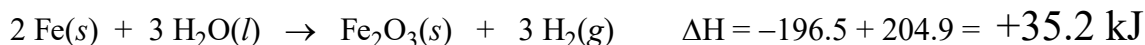
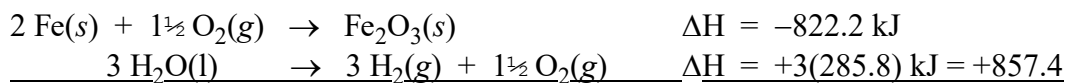
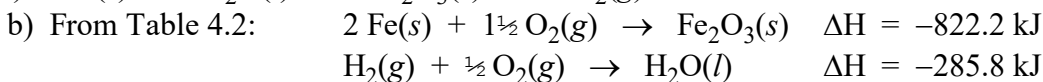
8. (Chapter 13/Equilibrium)
- Write a balanced chemical equation for the equilibrium reaction in which bromine gas and chlorine gas combine to form bromine chloride gas.
  - Write an expression for  $K$ , the equilibrium constant, for this reaction.
  - A one-liter flask initially contains 0.70 M bromine and 0.55 M chlorine. When the system reaches equilibrium, the bromine concentration is 0.35 M. Calculate the value for  $K$  for this system.
9. (Chapter 13/Equilibrium)
- For the system at equilibrium,
 
$$2 \text{NO}_2(g) \rightleftharpoons \text{N}_2\text{O}_4(g) \quad \Delta H = -58 \text{ kJ,}$$
 what affect will each of the following have?
    - decreasing the volume
    - increasing the temperature
    - adding a catalyst
    - adding more  $\text{N}_2\text{O}_4$
  - Write an expression for  $K$  for this equilibrium. Calculate  $[\text{N}_2\text{O}_4]$  if the  $[\text{NO}_2] = 0.010 \text{ M}$  when the value for  $K$  is 10.0.
10. (Chapter 14/pH) Find the pH of each of the following solutions:
- 0.0050 M  $\text{HClO}_4$
  - 1.0 g NaOH dissolved in 250 ml water
  - a 0.10 M solution of a weak acid with a  $K_a$  of  $10^{-7}$
  - 0.00435 M  $\text{NaHCO}_3$  ( $K_b$  for  $\text{HCO}_3^-$  is  $2.3 \times 10^{-8}$ ).
11. (Chapter 15/Buffers)
- What is the pH of a buffer made up of 100 mL of 0.10 M HF and 174 mL of 0.10 M NaF?
  - What ratio of  $\text{ClO}^-/\text{HClO}$  is needed to produce a buffer with a pH of 7.4?
12. (Chapter 15/Titration)
- What is the molar mass of an acid, if 0.864 grams of the acid are neutralized by 36.0 ml of 0.400 M NaOH?
  - What is the molarity of an  $\text{NH}_3$  solution if 12.0 liters of the  $\text{NH}_3$  solution are neutralized by 360 ml of 4.00 M HCl?
13. (Chapter 16/ $K_{sp}$ )
- The  $K_{sp}$  for zinc hydroxide is  $4.5 \times 10^{-17}$ . Find the concentration of zinc hydroxide dissolved in a saturated solution.
  - What concentration of potassium hydroxide must be added to 0.0040 M zinc chloride to form a precipitate?
14. (Chapter 18/Oxidation-Reduction) For the following oxidation-reduction equation:
- $$\text{NO}_3^-(aq) + \text{Cu}(s) \rightarrow \text{NO}(g) + \text{Cu}^{2+}(aq)$$
- Balance the equation adding  $\text{H}^+$  and  $\text{H}_2\text{O}$  as needed.
  - Use standard reduction potentials to determine  $E^\circ$  for the reaction.
  - Which substance is acting as an oxidizing agent? as a reducing agent?

## Answers to Spring Examination Study Questions

1.  $Q = C \times m \times \Delta T$ ;  $Q = 58.5 \text{ kJ} = 58,500 \text{ J}$ ;  $m = ?$ ;  $\Delta T = 77.2 - 21.2 = 56.0^\circ\text{C}$ ;  $C = 4.18 \text{ J/g } ^\circ\text{C}$

$$m = \frac{Q}{C \times \Delta T} = \frac{58,500 \text{ J}}{4.18 \text{ J/g } ^\circ\text{C} \times 56.0 ^\circ\text{C}} = 250 \text{ g} = 2.50 \times 10^2 \text{ g} \quad (3 \text{ sig fig})$$

2. a)  $2 \text{ Fe}(s) + 3 \text{ H}_2\text{O}(l) \rightarrow \text{Fe}_2\text{O}_3(s) + 3 \text{ H}_2(g)$



- c) endothermic

3. a)  $V_1 = 5.60 \text{ L}$ ;  $P_1 = 1 \text{ atm}$ ,  $T_1 = 273 \text{ K}$ ;  $P_2 = ?$ ;  $V_2 = 18.0 \text{ L}$ ;  $T_2 = 78 + 273 = 351 \text{ K}$ .

$$P_2 = P_1 \times \frac{V_1}{V_2} \times \frac{T_2}{T_1} = 1.00 \text{ atm} \times \frac{5.60 \text{ L}}{18.0 \text{ L}} \times \frac{351 \text{ K}}{273 \text{ K}} = 0.400 \text{ atm}$$

- b)  $5.60 \text{ L} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = 0.250 \text{ mol}$ ; or use  $n = \frac{PV}{RT}$  at either T and P.

c) molar mass =  $\frac{\text{mass}}{\text{moles}} = \frac{7.50 \text{ g}}{0.250 \text{ mol}} = 30.0 \text{ g/mol}$

- d)  $\text{C}_2\text{H}_6$ , ethane,  $\text{CH}_3\text{--CH}_3$

4. a)  $2 \text{ Fe}(s) + 3 \text{ H}_2\text{O}(l) \rightarrow \text{Fe}_2\text{O}_3(s) + 3 \text{ H}_2(g)$

b)  $29.8 \text{ g Fe} \times \frac{1 \text{ mol Fe}}{55.85 \text{ g Fe}} \times \frac{3 \text{ mol H}_2}{2 \text{ mol Fe}} = 0.800 \text{ moles H}_2$

$$V = \frac{nRT}{P} = \frac{(0.800 \text{ mol})(0.8206)(390 \text{ K})}{1.60 \text{ atm}} = 16.0 \text{ L}$$

c)  $\text{mass}(\text{H}_2) = 0.800 \text{ mol} \times \frac{2.016 \text{ g}}{1 \text{ mol}} = 1.61 \text{ g}$ ; density =  $\frac{\text{mass}}{\text{volume}} = \frac{1.61 \text{ g}}{16.0 \text{ L}} = 0.101 \text{ g/L}$

5. a) moles particles =  $117 \text{ g NaCl} \times \frac{1 \text{ mol NaCl}}{58.5 \text{ g NaCl}} \times \frac{2 \text{ mol particles}}{1 \text{ mol NaCl}} = 4.00 \text{ mol particles}$

$$\Delta T_f = 1.86 \times \frac{4.00 \text{ mol particles}}{0.500 \text{ kg H}_2\text{O}} = 14.9^\circ\text{C}; T_f = 0 - 14.9^\circ\text{C} = -14.9^\circ\text{C}$$

b)  $\Delta T_f = 2.79^\circ\text{C}$ , moles = ?,  $50.0 \text{ g} = 0.0500 \text{ kg H}_2\text{O}$

$$\Delta T_f = 1.86 \times \frac{\text{mol particles}}{\text{kg H}_2\text{O}}; \text{ moles} = \frac{\Delta T_f \times \text{kg H}_2\text{O}}{1.86} = \frac{2.79 \times 0.0500}{1.86} = 0.0750 \text{ mol}$$

6. a)  $157 \text{ mL} \times \frac{3.00 \text{ mol NaNO}_3}{1 \text{ L}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{85.0 \text{ g NaNO}_3}{1 \text{ mol NaNO}_3} = 40.0 \text{ g NaNO}_3$

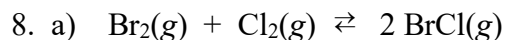
b) Review how to prepare a solution from either solid solute or by diluting a concentrated solution: see Procedure from the "Solution Preparation" Experiment.

c)  $V_1 \times M_1 = V_2 \times M_2$ ;  $V_1 = 240 \text{ mL}$ ;  $M_1 = 0.500 \text{ M}$ ;  $V_2 = 2.00 \text{ L} = 2000 \text{ mL}$ ;  $M_2 = ?$

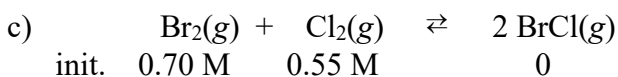
$$M_2 = \frac{V_1 \times M_1}{V_2} = \frac{240 \text{ mL} \times 0.500 \text{ M}}{2000 \text{ mL}} = 0.0600 \text{ M}$$

d)  $\frac{26.0 \text{ g NaNO}_3}{100 \text{ g solution}} \times \frac{1.19 \text{ g solution}}{1 \text{ mL solution}} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{1 \text{ mol NaNO}_3}{85.0 \text{ g NaNO}_3} = 3.64 \text{ M}$

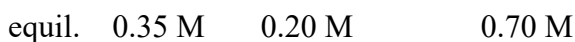
7. a) **concentration of reactants:** Reaction rate increases as concentration of reactants increases because number of collisions increases, making reaction more likely to occur.  
 b) **surface area of reactants:** Rate increases as surface area of reactants increases because the greater the area of reactant exposed, the more likely are collisions that will result in product formation.  
 c) **temperature:** As temperature increases, rate increases because at higher temperature, a greater proportion of reactant molecules have a kinetic energy greater than the activation energy so a greater proportion of collisions result in product formation.  
 d) **catalyst:** Catalysts increase reaction rate by lowering the activation energy.



b)  $K = \frac{[\text{BrCl}]^2}{[\text{Br}_2][\text{Cl}_2]}$



$\Delta$	-0.35 M	-0.35 M	+0.70 M	$K = \frac{[0.70]^2}{[0.35][0.20]} = 7.0$
equil.	0.35 M	0.20 M	0.70 M	



9. a) i) shift to right (shift to side with fewer moles); ii) shift to the left (shift in endothermic direction to use up heat); iii) no shift; iv) shift to left (use up some of the  $N_2O_4$  added).

$$b) K = \frac{[N_2O_4]}{[NO_2]^2}; [N_2O_4] = K \times [NO_2]^2 = 10.0 (0.010)^2 = 0.0010 \text{ M}$$

10. a)  $HClO_4$  = strong acid, so  $[HClO_4] = [H^+] = 0.0050 \text{ M}$ ;  $pH = -\log(0.0050) = 2.3$

$$b) NaOH = \text{strong base, so } [NaOH] = [OH^-] = \frac{1 \text{ g NaOH}}{0.250 \text{ L}} \times \frac{1 \text{ mol NaOH}}{40.0 \text{ g NaOH}} = 0.10 \text{ M NaOH}$$

$$[OH^-] = 0.10 \text{ M} = 1 \times 10^{-1} \text{ M}; [H^+] = 1 \times 10^{-13} \text{ M}; pH = 13.0$$

$$c) K_a = \frac{[H^+][A^-]}{[HA]}; [H^+] = [A^-] = x; [HA] \approx 0.10 \text{ M}; 1.0 \times 10^{-7} = \frac{x^2}{0.10 \text{ M}}$$

$$x^2 = (1.0 \times 10^{-7})(0.10) = 1.0 \times 10^{-8} \text{ M}; x = [H^+] = 1.0 \times 10^{-4} \text{ M}; pH = 4.0$$

$$d) HCO_3^- + H_2O \rightleftharpoons H_2CO_3 + OH^-; K_b = \frac{[H_2CO_3][OH^-]}{[HCO_3^-]}; x = [OH^-] = [H_2CO_3]$$

$$2.3 \times 10^{-8} = \frac{x^2}{(0.00435)}; x^2 = (2.3 \times 10^{-8})(0.00435) = 1.0 \times 10^{-10}$$

$$x = [OH^-] = (1.0 \times 10^{-10})^{1/2} = 1.0 \times 10^{-5} \text{ M}; pOH = 5.0; pH = 9.0$$

$$11. a) pH = pK_a + \log \frac{[F^-]}{[HF]}; pK_a(HF) = -\log(7.2 \times 10^{-4}) = 3.14; \frac{[F^-]}{[HF]} = \frac{174}{100} = 1.74$$

$$pH = 3.14 + \log(1.74) = 3.14 + 0.24 = 3.40; pH = 3.40$$

$$b) K_a(HClO) = 3.5 \times 10^{-8}; [H^+] = 10^{-7.4} \text{ M} = 4.0 \times 10^{-8} \text{ M}$$

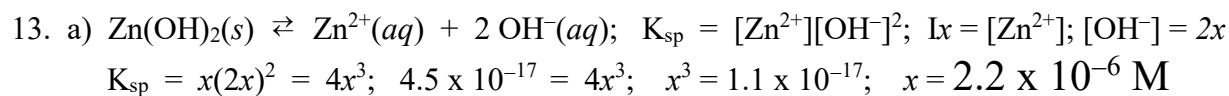
$$\frac{K_a}{[H^+]} = \frac{[ClO^-]}{[HClO]} = \frac{3.5 \times 10^{-8}}{4.0 \times 10^{-8}} = 0.88$$

$$12. a) \text{ moles acid} = \text{ moles base} = 0.0360 \text{ L} \times \frac{0.400 \text{ mol}}{1 \text{ L}} = 0.0144 \text{ moles}$$

$$\text{molar mass} = \frac{\text{mass}}{\text{moles}} = \frac{0.864 \text{ g}}{0.0144 \text{ mol}} = 60.0 \text{ g/mol}$$

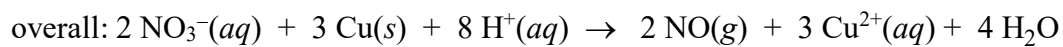
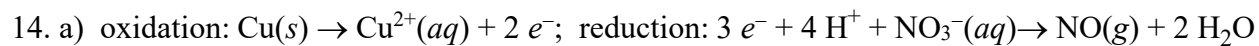
$$b) \text{ since moles acid} = \text{ moles base: } V_A \times M_A = V_B \times M_B$$

$$0.360 \text{ L} \times 4.00 \text{ M} = 12.0 \text{ L} \times M_B; M_B = \frac{0.360 \times 4.00}{12.0} = 0.120 \text{ M}$$



$$4.5 \times 10^{-17} = (0.0040)(x)^2$$

$$x^2 = (4.5 \times 10^{-17}) / (0.0040); x = (1.1 \times 10^{-14})^{1/2} = 1.1 \times 10^{-7} \text{ M}$$



b)  $E^\circ = E^\circ_{\text{ox}}(\text{Cu}) + E^\circ_{\text{red}}(\text{NO}_3^-) = -0.34 \text{ v} + 0.96 \text{ v} = 0.62 \text{ volts}$

c)  $\text{NO}_3^-$  is the oxidizing agent (it's reduced); Cu is the reducing agent (it's oxidized).