

NATIONAL HIGH SCHOOL CHEMISTRY EXAMINATION (1996)

PART ONE – MULTIPLE CHOICE

- The ion which has 35 protons, 44 neutrons and 36 electrons is:  
 A.  $^{79}\text{K}^+$       B.  $^{79}\text{Br}^+$       C.  $^{80}\text{Kr}^+$       D.  $^{80}\text{Br}^-$       E.  $^{79}\text{Br}^-$
- An element X forms two oxides whose formulas are  $\text{XO}_3$  and  $\text{X}_2\text{O}_3$ . One of these oxides contains 52% of X by mass and has a molar mass of 99.98. What is the formula of this oxide?  
 A.  $\text{Mg}_2\text{O}_3$       B.  $\text{K}_2\text{O}_3$       C.  $\text{CrO}_3$       D.  $\text{Al}_2\text{O}_3$       E.  $\text{VO}_3$
- Ammonia ( $\text{NH}_3$ ) reacts with fluorine ( $\text{F}_2$ ) to form dinitrogen tetrafluoride ( $\text{N}_2\text{F}_4$ ) and HF. In this reaction, how much fluorine can react with 17.0 g of ammonia?  
 A. 119 g      B. 95.0 g      C. 38.0 g      D. 190 g      E. 47.5 g
- Platinum is a useful and relatively inert metal, but it will dissolve in aqua regia, a mixture of nitric and hydrochloric acids.  
 The reaction is  $3 \text{Pt}(\text{s}) + 4 \text{HNO}_3(\text{aq}) + 18 \text{HCl}(\text{aq}) \rightarrow 3 \text{H}_2\text{PtCl}_6(\text{aq}) + 4 \text{NO}(\text{g}) + 8 \text{H}_2\text{O}(\text{l})$   
 How many grams of nitric oxide (NO) are formed when 11.6 g of Pt dissolves?  
 A. 14.98 g      B. 1.78 g      C. 1.34 g      D. 2.38 g      E. 7.13 g
- The aqua regia can be prepared with concentrated nitric acid whose concentration is 16M (16 mol/L). What volume of this acid would be required for complete reaction with 11.6 g of Pt?  
 A. 35.5 mL      B. 312 mL      C. 2.79 mL      D. 3.72 mL      E. 4.95 mL
- Which of the following ions has the largest radius?  
 A.  $\text{S}^{2-}$       B.  $\text{K}^+$       C.  $\text{F}^-$       D.  $\text{Cl}^-$       E.  $\text{O}^{2-}$
- The radioactive isotope Na-24 is used to observe the circulation of blood. What isotope is produced when Na-24 decays by emitting a beta particle, which is a fast-moving electron?  
 A. Mg-24      B. Na-25      C. Ne-23      D. Na-23      E. Mg-25
- Oxygen condenses at  $-183^\circ\text{C}$  and freezes at  $-223^\circ\text{C}$ . According to the kinetic molecular theory, the kinetic energy of oxygen molecules is zero at  
 A.  $-183^\circ\text{C}$       B.  $-273^\circ\text{C}$       C.  $-373^\circ\text{C}$       D.  $-223^\circ\text{C}$       E.  $0^\circ\text{C}$

9. Benzoic acid,  $C_7H_6O_2$ , is found in certain berries. A sample of 1.425 g of benzoic acid is burned in a combustion calorimeter, and the temperature increases from  $23.60^\circ\text{C}$  to  $32.33^\circ\text{C}$ . The calorimeter has a heat capacity of  $893\text{ J K}^{-1}$ , and it contains 775 g of water whose specific heat is  $4.184\text{ J K}^{-1}\text{ g}^{-1}$ . How much heat is released by the combustion of the sample?
- A. 14.6 kJ                  B. 51.4 kJ                  C. 25.3 kJ                  D. 36.1 kJ                  E. 28.3 kJ
10. Find the enthalpy change ( $\Delta H$ ) for the reaction:  $C_2H_4(g) + 6 F_2(g) \rightarrow 2 CF_4(g) + 4 HF(g)$  using the following thermochemical data:
- $C(s) + 2 F_2(g) \rightarrow CF_4(g) \quad \Delta H = -680\text{ kJ}$   
 $2 C(s) + 2 H_2(g) \rightarrow C_2H_4(g) \quad \Delta H = +52\text{ kJ}$   
 $H_2(g) + F_2(g) \rightarrow 2 HF(g) \quad \Delta H = -537\text{ kJ}$
- A. -2382 kJ                  B. -3560 kJ                  C. -1269 kJ                  D. -2486 kJ                  E. -1165 kJ
11. An automobile cylinder has a volume of 450 cc. The engine takes in air at a pressure of 1.00 atm and a temperature of  $27^\circ\text{C}$ , and compresses it to a volume of 50.0 cc at  $77^\circ\text{C}$ . What is the final pressure of air in the cylinder?
- A. 1.17 atm                  B. 7.7 atm                  C. 9.0 atm                  D. 25.7 atm                  E. 1.66 atm
12. Nickel tetracarbonyl,  $Ni(CO)_4$ , is formed by the reaction of nickel metal and carbon monoxide. If 0.118 g of nickel reacts at  $21^\circ\text{C}$  with 570 mL of CO at an initial pressure of 2.00 atm, what is the pressure of CO after the reaction?
- A. 0.34 atm                  B. 0.64 atm                  C. 1.92 atm                  D. 0.085 atm                  E. 1.66 atm
13. Which substance would you expect to have the highest melting point.
- A.  $GeI_4$                   B.  $I_2$                   C. KI                  D.  $CH_3I$                   E. HI
14. Solid  $CO_2$  is called "dry ice", because it changes directly from a solid to a gas at  $-78^\circ\text{C}$  without ever becoming liquid (at 1 atm pressure). When solid  $CO_2$  becomes a gas:
- A. Its energy decreases and its entropy decreases  
 B. Its energy is constant and its entropy increases  
 C. Its energy decreases and its entropy increases  
 D. Its energy increases and its entropy increases  
 E. Its energy increases and its entropy decreases

15. If the intermolecular forces in liquid A are stronger than in liquid B, then compared to liquid A:
- Liquid B has a lower boiling point and a lower vapor pressure at 25°C
  - Liquid B has a lower boiling point and a higher vapor pressure at 25°C
  - Liquid B has a higher boiling point and a lower vapor pressure at 25°C
  - Liquid B has a higher boiling point and the same vapor pressure at 25°C
  - Liquid B has a higher boiling point and a higher vapor pressure at 25°C
16. An antifreeze mixture consists of 40% ethylene glycol (C<sub>2</sub>H<sub>6</sub>O<sub>2</sub>) by weight in aqueous solution. If the density of this solution is 1.05 g/mL, what is the molar concentration?
- 6.77 M
  - 6.45 M
  - 0.017 M
  - 16.9 M
  - 7.11 M
17. The decomposition reaction  $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$  has an equilibrium constant of 0.245 at 300°C. What happens in a container which contains the three gases each at a concentration of 0.30 mol/L?
- The concentration of PCl<sub>5</sub> increases and those of PCl<sub>3</sub> and Cl<sub>2</sub> decrease
  - The concentrations of Cl<sub>2</sub> and PCl<sub>5</sub> increase and that of PCl<sub>3</sub> decreases
  - The concentration of PCl<sub>3</sub> and Cl<sub>2</sub> increase and that of PCl<sub>5</sub> decreases
  - The concentration of PCl<sub>3</sub> and PCl<sub>5</sub> increase and that of Cl<sub>2</sub> decreases
  - The mixture remains in a state of equilibrium
18. How would you increase the yield of products at equilibrium in the reaction
- $$\text{SO}_2(\text{g}) + \text{NO}_2(\text{g}) \rightleftharpoons \text{SO}_3(\text{g}) + \text{NO}(\text{g}) \quad H = -42 \text{ kJ}$$
- Assume that all the gases behave ideally.
- Add a catalyst
  - Decrease the volume
  - Increase the volume
  - Decrease the temperature
  - Increase the temperature
19. The common automobile battery contains
- carbonic acid (H<sub>2</sub>CO<sub>3</sub>)
  - sulphuric acid (H<sub>2</sub>SO<sub>4</sub>)
  - hydrochloric acid (HCl)
  - acetic acid (C<sub>2</sub>H<sub>4</sub>O<sub>2</sub>)
  - nitric acid (HNO<sub>3</sub>)

20. The ion  $\text{H}_2\text{PO}_4^-$  can act as either an acid or a base. Its conjugate base and acid are respectively
- A.  $\text{H}_3\text{PO}_4$  and  $\text{HPO}_4^{2-}$       B.  $\text{HPO}_4^{2-}$  and  $\text{H}_3\text{PO}_4$       C.  $\text{PO}_4^{3-}$  and  $\text{HPO}_4^{2-}$   
 D.  $\text{H}_3\text{PO}_4$  and  $\text{PO}_4^{3-}$       E.  $\text{PO}_4^{3-}$  and  $\text{H}_3\text{PO}_4$
21. What is the pH of a solution of  $10^{-9}$  M NaOH?
- A. 9      B. 7      C. 6      D. 5      E. 8
22. A 0.01 M solution of a certain weak acid (HA) has a pH of 5.0. What is the ionization constant ( $K_a$ ) of this acid?
- A.  $1.0 \times 10^{-12}$       B.  $1.0 \times 10^{-5}$       C.  $1.0 \times 10^{-7}$       D.  $1.0 \times 10^{-8}$       E.  $1.0 \times 10^{-3}$
23. The solubility of AgBr in pure water is  $5.7 \times 10^{-7}$  M (at 25°C). What is the solubility of AgBr in a solution which contains 0.01 mol of NaBr per litre?
- A.  $3.25 \times 10^{-13}$  M      B.  $5.7 \times 10^{-5}$  M      C.  $7.55 \times 10^{-5}$  M      D.  $5.7 \times 10^{-7}$  M      E.  $3.25 \times 10^{-11}$  M
24. The reaction  $\text{CO}(\text{g}) + \text{NO}_2(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + \text{NO}(\text{g})$  is second order in  $\text{NO}_2$  and zero order in CO. If the concentration of CO is doubled and that of  $\text{NO}_2$  is halved, the reaction rate will be:
- A. halved      B. divided by 4      C. multiplied by 4      D. unchanged      E. doubled
25. The reduction potentials of silver and nickel are  $E(\text{Ag}^+, \text{Ag}) = +0.80$  V and  $E(\text{Ni}^{2+}, \text{Ni}) = -0.25$  V. Which of the following statements is true?
- A.  $\text{Ag}^+$  is an oxidizing agent but  $\text{Ni}^{2+}$  is a reducing agent  
 B.  $\text{Ag}^+$  is a better oxidizing agent than  $\text{Ni}^{2+}$  and Ag is a better reducing agent than Ni  
 C.  $\text{Ni}^{2+}$  can be reduced by silver metal  
 D.  $\text{Ag}^+$  is a better oxidizing agent than  $\text{Ni}^{2+}$  and Ni is a better reducing agent than Ag  
 E.  $\text{Ni}^{2+}$  is a better oxidizing agent than  $\text{Ag}^+$  and Ag is a better reducing agent than Ni

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PART TWO - ESSAY QUESTIONS (Choose 3)

Answer THREE questions only in the form of scientific essays including any appropriate equations, formulas and diagrams. The judging of the essays will be based on both factual accuracy and presentation. A clear, concise and well-organized essay will be rated higher than a long rambling one which contains the same information.

1. The 1995 Nobel Prize in Chemistry was awarded to three scientists who discovered possible danger to the earth's ozone layer. Discuss the problem of the ozone layer: where is it found, how is it formed, why is it important, and what is the nature of the danger?
2. Describe the properties and importance of three of the six alkaline earth metals. (Be, Mg, Ca, Sr, Ba, Ra)
3. Explain the different types of bonds between atoms, both strong and weak. How is each type of bond formed? In what substances is each type of bond found? What are their relative strengths?
4. Chemical analysis (or analytical chemistry) deals with methods of determining the compositions of mixtures. Explain some methods for determining the concentration of a substance in a mixture.
5. What is an oxidation-reduction reaction? Give a variety of examples both with and without the breaking of chemical bonds. Give some examples of oxidation-reduction reactions which are useful and explain their use.