NATIONAL HIGH SCHOOL CHEMISTRY EXAMINATION (1995)

PART ONE – MULTIPLE CHOICE

1. Mercury(I) compounds contain a diatomic cation whose formula is Hg_2^{2+}. The total number of electrons in this ion is

   a) 156 b) 158 c) 159 d) 160 e) 162

2. Elements X and Y can combine to form two different compounds. If 1.60 g of X reacts with exactly 1.60 g of Y, the compound produced has the formula XY_2. However, under different conditions, 2.40 g of X will react with 1.60 g of Y to form a second compound, whose empirical formula is

   a) X_3Y_4 b) XY c) XY_3 d) X_2Y e) X_4Y_3

3. Benzene (C_6H_6) can react with fluorine according to the unbalanced chemical equation

   $$C_6H_6 + F_2 \rightarrow C_6F_{12} + HF$$

   If this equation is balanced, the number of moles of F_2 required to react with each mole of C_6H_6 is

   a) 18 b) 12 c) 9 d) 6 e) 3

4. Given the balanced equation

   $$3\ Cu(s) + 8\ HNO_3(aq) \rightarrow 3\ Cu(NO_3)_2(aq) + 2\ NO(g) + 4\ H_2O(l)$$

   determine the mass of copper that would produce 0.167 mol NO(g) when reacted with excess nitric acid.

   a) 10.6 g b) 31.8 g c) 190.6 g d) 5.01 g e) 15.9 g

5. A 1.56 g sample of a compound containing only carbon and hydrogen was completely burned. The reaction produced 5.28 g of CO_2 and 1.08 g of H_2O. What is the empirical formula of the compound?

   a) CH_2 b) C_5H_3 c) C_2H_5 d) C_3H_7 e) CH

6. Which one of the following has the largest radius?

   a) the Na atom b) the Mg atom c) the Ca^{2+} ion d) the K atom e) the Ca atom

7. In which one of the following lists are all the substances covalently bonded?

   a) NO, HBr, LiOH b) CO_2, NH_3, F_2 c) CO, $BaCl_2$, N_2

   d) CH_4, H_2O, Ne e) NaF, CCl_4, $Al(OH)_3$

8. At room temperature fluorine is a gas (boiling point –188°C), while bromine is a liquid (boiling point +59°C). The difference in the physical states of these two halogens occurs because

   a) the intermolecular forces in bromine are weaker

   b) the covalent bonds in bromine are stronger

   c) the intermolecular forces in bromine are stronger

   d) the covalent bonds in bromine are weaker

   e) the covalent bonds in bromine are more polar

9. Which of the following statements about ionic compounds is FALSE?

   a) Ionic bonding is due top electrostatic attraction

   b) Every ion is charged

   c) The formation of a binary ionic compound from its elements is exothermic

   d) Every ion contains only one nucleus and a number of electrons which is different from the nuclear charge

   e) Ionic compounds which dissolve in water form conducting solutions

10. The following thermochemical equations apply to the reactions of iron with dioxygen:

   $Fe(s) + 1/2\ O_2(g) \rightarrow FeO(s) + 133.2\ kJ$

   $2\ Fe(s) + 3/2\ O_2(g) \rightarrow Fe_2O_3(s) + 738.1\ kJ$

   How much heat is evolved in the reaction: $2\ FeO(s) + 1/2\ O_2(g) \rightarrow Fe_2O_3(s)$?

   a) 1004.5 kJ b) 871.3 kJ c) 471.7 kJ d) 604.9 kJ e) 1343.0 kJ

11. By photosynthesis using solar energy, maple trees make molecules of glucose in the reaction

   $6\ CO_2(g) + 6\ H_2O(l) \rightarrow C_6H_{12}O_6(s) + 6\ O_2(g) \quad \Delta H = +2815\ kJ/mol\ glucose$

   To make 20 g of glucose, how much solar energy must the maple leaves absorb (if the process is 100% efficient)?

   a) 239 kJ b) 469 kJ c) 141 kJ d) 313 kJ e) 15.6 kJ

12. A student generates 41.0 mL of dihydrogen (H_2) by reacting solid magnesium with hydrochloric acid at 20°C. He then heats the gas produced to 35°C without changing the pressure. What will be the final volume of H_2?

   a) 43.1 mL b) 71.8 mL c) 39.0 mL d) 23.4 mL e) 80.5 mL

13. At 70°C and atmospheric pressure of 101.3 kPa, a light bulb with a volume of 212 mL contains 0.152 g of a pure gas. What is this gas?

   a) Ne b) Ar c) Kr d) N_2 e) O_2

14. Two containers are filled with gas at the same temperature, one with H_2 and the other with CO_2. Which one of the following statements is consistent with the kinetic theory of gases?

    a) The molecules of the two gases have the same average speed.

    b) The molecules of the two gases have the same average kinetic energy.

    c) All the molecules of the two gases have the same kinetic energy.

    d) All of the molecules of the two gases have the same speed.

    e) None of the above.

15. An aqueous solution of concentrated hydrobromic acid contains 48% HBr by mass. If the density of the solution is 1.50 g/mL, what is its concentration?

    a) 11.4 mol/L b) 8.9 mol/L c) 5.9 mol/L d) 18.5 mol/L e) 40.0 mol/L

16. In a certain solution the concentration of the OH^- ion is 100 times greater than the concentration of the H^+ ion. What is the pH of this solution?

    a) 8b) 12 c) 6 d) 2 e) 14

17. Chlorine is a pale yellow-green gas, which, when dissolved in water, produces an aqueous solution that

    a) has a pH more acidic than 7, and has no redox properties.

    b) has a pH more basic than 7 and is an oxidizing agent.

    c) is neutral and is a reducing agent.

    d) has a pH more acidic than 7 and is an oxidizing agent.

    e) has a pH more acidic than 7 and is a reducing agent.

18. Formic acid (HCO_2H) is a weak monoprotic acid in aqueous solution.

    An aqueous solution is made by dissolving 1.00 mol of formic acid in sufficient water to make 1.00 L of solution. Which one of the following species is present in largest concentration?

    a) H_3O^+ b) OH^- c) HCO_2^- d) HCO_2H

    e) insufficient information is given to decide

19. Pure solid ammonium carbamate ($NH_4CO_2NH_2$) is put into a vessel which already contained ammonia at a partial pressure of 10.1 kPa. The solid ammonium carbamate is allowed to dissociate according to the equation:

    $$NH_4CO_2NH_2(s) \rightarrow 2\ NH_3(g) + CO_2(g)$$

The total pressure of the gases in equilibrium with the solid is 14.4 kPa. Calculate the value of the equilibrium constant K_p.

a) 1503 kPa^2 b) 16.5 kPa^2 c) 43 kPa^2 d) 241 kPa^2 e) 14.6 kPa^2

20. Consider the equilibrium in the gaseous state

$N_2(g) + O_2(g) \rightarrow 2\ NO(g)$ $\Delta H = +180.5$ kJ

Which of the following changes will displace the equilibrium and increase the number of moles of NO present?

a) reduce the temperature

b) increase the pressure by reducing the volume

c) add oxygen

d) add a catalyst

e) remove nitrogen

21. A chemist finds the following values for the initial rate of the reaction

$2\ A(g) + B(g) \rightarrow C(g)$

Concentration [A} (mol/L)	0.50	1.0	1.0	1.5	1.0
Concentration [B] (mol/L)	0.50	0.50	1.0	1.0	1.5
Initial rate (mol/h)	0.020	0.080	0.080	0.18	0.080

The rate law expression for this reaction is

a) rate = k [A] [B] b) rate = k $[A]^2$ [B] c) rate = k $[A]^2$ $[B]^2$

d) rate = k $[A]^2$ e) rate = k $[B]^2$

22. What is the oxidation state of manganese in $KMnO_4$?

a) +1 b) +5 c) +7 d) +2 e) +6

23. In the electrolysis of molten sodium chloride the reduction reaction is

a) $Na \rightarrow Na^+ + e^-$ b) $Na^+ + e^- \rightarrow Na$

c) $2\ Cl^- \rightarrow Cl_2 + 2\ e^-$ d) $2\ H^+ + 2\ e^- \rightarrow H_2$

e) $Cl_2 + 2\ e^- \rightarrow 2\ Cl^-$

24. A student mixed aqueous solutions of the following ionic compounds, and made the observations listed in the table:

Solution A	Solution B	Observations
$Ba(ClO_3)_2$	$Mg(IO_3)_2$	a white precipitate formed

$Mg(IO_3)_2$	$Pb(ClO_3)_2$	a white precipitate formed
$MgCrO_4$	$Pb(ClO_3)_2$	a yellow precipitate formed
$MgCrO_4$	$Ca(ClO_3)_2$	no observable reaction

From these data, she can conclude that

a) both $Ba(IO_3)_2$ and $Mg(ClO_3)_2$ are insoluble in water.

b) both $PbCrO_4$ and $Mg(ClO_3)_2$ are insoluble in water.

c) $Ba(IO_3)_2$, $Pb(IO_3)_2$, and $PbCrO_4$ are insoluble in water.

d) all of $Ba(IO_3)_2$, $Mg(ClO_3)_2$, $Pb(IO_3)_2$, $PbCrO_4$, and $CaCrO_4$ are insoluble in water.

e) only $Ba(IO_3)_2$ and $PbCrO_4$ are insoluble in water.

25. The solubility product constant of BiI_3 is 8.2×10^{-19}. The solubility of this salt in pure water is therefore

a) 9.1×10^{-10} mol/Lb) 3.0×10^{-5} mol/L

c) 2.1×10^{-19} mol/L d) 5.9×10^{-7} mol/L

e) 1.3×10^{-5} mol/L

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PART TWO - ESSAY QUESTIONS

Discuss THREE of the following five topics in essay form. These are to be scientific essays and therefore equations, formulas ,diagrams, etc., are highly appropriate. A clear, concise and well-organized essay will be rated higher than a long rambling one which contains the same information.

1. this year is the 100th anniversary of the discovery of X-rays and next year will be the 100th anniversary of radioactivity. Today the words "radiation" and "radioactivity" may bring to mind both positive and negative reactions. Describe the main forms of ionizing radiation, and explain the positive and negative effects of their use on our quality of life.

2. Acids and bases are two very important classes of substances, but several different definitions of these terms are used by chemists. Explain the various definitions of acids and bases, and give examples of substances which are acidic and basic according to each definition.

3. Describe an experiment which would allow you to measure the heat (or enthalpy change) of a chemical reaction. Suggest a specific reaction and describe the apparatus which you would use and the procedure which you would follow. What type of results would you expect and how would you interpret the data?

4. About 90% of the chemical substances which have been discovered are compounds of carbon, also known as organic compounds. Describe the structures and properties of some classes of organic compounds,as well as their importance in our lives.

5. What is a catalyst? Describe some commonly used types of catalyst, and indicate the types of reactions which they can catalyse.