THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Secondary School Mathematics & Science Competition

Chemistry

Date : 19-05-2012 Total no. of pages : 18

Time allowed : 11:00 – 12:15 pm (1 hour 15 minutes) Total marks : 60

Instructions:

1. Write your Name, School Name, Subject Name, Date and Student Number in the spaces provided on the answer sheet.
2. When told to open this book, you should check that all the questions are there. Look for the words '**END OF PAPER**' after the last question.
3. **Answer ALL questions in PART A and any FIVE out of six questions in PART B.**
4. Diagrams in this paper are **NOT** necessarily drawn to scale.
5. The paper is divided into two parts. Part A consists of forty Multiple Choice questions and Part B six short questions.

PART A (Multiple Choice Questions)

(a) You should use an HB pencil to mark all your answers on the Answer Sheet.

(b) Each question carries one mark.

(c) You should mark only ONE answer for each question. If you mark more than one answer, you will receive NO MARKS for that question.

(d) No marks will be deducted for wrong answers.

PART B (Short Questions)

(a) Choose any five out of the six questions.

(b) Answers should be written in the space provided on the answer sheet.

Section A：Multiple Choice Questions (40 marks)

1. Rock salt is a mixture of sodium chloride and sand. What is the correct procedure to purify sodium chloride using water as solvent?

   A. dissolving → crystallizing → filtering →evaporating
   B. evaporating → filtering → dissolving → crystallizing
   C. dissolving → filtering → evaporating → crystallizing
   D. filtering → dissolving → crystallizing → evaporating

2. Which of the following pairs have isotopes?

   A. ${}^{16}_{8}X$ and ${}^{18}_{8}X$
   B. ${}^{52}_{24}X$ and ${}^{53}_{25}X$
   C. ${}^{4}_{2}X$ and ${}^{20}_{10}X$
   D. ${}^{40}_{19}X$ and ${}^{40}_{20}X$

3. Elements A and B are in the same group in the periodic table. Which of the following statements about elements A and B is correct?

   A. They have same boiling points.
   B. They have same atomic size.
   C. They have similar chemical properties.
   D. They have similar physical properties.

4. Which of the following statements about periodic table is correct?

   A. Across a period, all elements have decreasing boiling point.
   B. Down a group, all elements have the same types of bonding.
   C. Down a group, atomic size is increasing.
   D. Elements are arranged in increasing order of relative atomic mass.

5. What is the maximum amount of carbon dioxide obtained by burning a mixture of 2.80 g of carbon monoxide and 6.40 g of oxygen gas? (Atomic mass: Carbon =12.0, Oxygen = 16.0)

A. 2.20 g

B. 4.40 g

C. 8.80 g

D. 9.20 g

6. Para-cresol is used as a disinfectant and in the manufacture of herbicides. A 0.404 g sample of this carbon-hydrogen-oxygen compound yields 1.15 g CO_2 and 0.269 g H_2O in combustion analysis. The molecular weight of para-cresol is 108 g mol^{-1}. Determine the molecular formula of para-cresol. (Atomic mass: hydrogen = 1.00, Carbon =12.0, Oxygen = 16.0)

A. C_7H_7O

B. $C_6H_{20}O$

C. $C_6H_4O_2$

D. C_7H_8O

7. X, Y and Z are three metal strips. When each is wrapped to an iron nail and immersed in a potassium hexacyanoferrate(III) solution (see diagram below). Only dish 2 shows rusting of the iron nail. The oxides of X and Y are reduced to metals by heating with carbon, but not Z. Based on these results, arrange in an increasing order the activity of X, Y and Z towards oxidation.

X strip + iron nail

Dish 1

Y strip + iron nail

Dish 2

Z strip + iron nail

Dish 3

A. Y, X, Z

B. X, Z, Y

C. Y, Z, X

D. Z, X, Y

8. Cisplatin, $PtCl_2(NH_3)_2$, is an anti-tumor drug. It is administered via a solution of iodized poppy-seed oil as fine solid particles. If the molecular weight of cisplatin is 300 g mol^{-1}, how many atoms of platinum are there in 30 g of cisplatin? (Take Avogadro's Constant = 6.02×10^{23})

A. 2.01×10^{22} atoms
B. 6.02×10^{22} atoms
C. 2.01×10^{21} atoms
D. 6.02×10^{24} atoms

9. A litmus paper can be used to distinguish acids from bases. When a student tested a liquid with a blue litmus paper, it remained blue. This shows that the liquid

A. must be pure water.
B. is neither an acid nor a base.
C. is not an acid.
D. must be a base.

10. An oxide layer on the surface of zinc can be removed by

A. Ammonia solution
B. Dilute hydrochloric acid
C. Sodium carbonate solution
D. Sodium hydroxide pellets

11. The pH of a sulphuric solution is 1.43. What is the concentration of the acid?

A. 0.0186 M
B. 0.0372 M
C. 0.0777 M
D. 0.155 M

12. What is the volume of 2.50 M sulphuric acid required to react with 7.98 g of iron(III) oxide for complete neutralization?

A. 40.0 cm^3

B. 60.0 cm^3

C. 80.0 cm^3

D. 100 cm^3

13. A 0.850 g of sodium carbonate is dissolved in 100 cm^3 of water and 25.0 cm^3 of the solution is drawn out into a conical flask. What is the concentration of the 25.0 cm^3 solution?

A. 2.00×10^{-2} M

B. 4.00×10^{-2} M

C. 8.00×10^{-2} M

D. 3.20×10^{-1} M

14. Which of the following product is NOT derived from crude oil?

A. Polyester

B. Detergent

C. Nylon

D. Glass wool

15. Hydrocarbon compounds A and B are in the same homologous series. Which of the following is CORRECT?

A. They have the same physical property

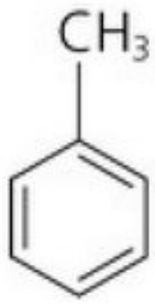
B. They have the same chemical property.

C. They have the same empirical formula.

D. They have the same number of carbon.

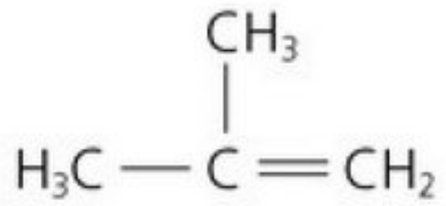
16. Which of the following would most readily undergo addition reaction?

A.

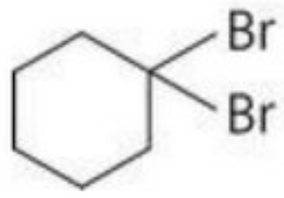


B.

C.



D.



17. Which of the following gas molecule is NOT linear in shape?

A. Carbon dioxide
B. Beryllium chloride
C. Sulphur dioxide
D. Ethyne

18. Which of the following molecule does not obey the Octet rule?

A. PCl_5
B. NCl_3
C. H_2O
D. NH_4^+

19. Which of the following is NOT a redox reaction?

A. $H_2O(l) + SO_2(g) \rightarrow H_2SO_3(aq)$
B. $H_2(g) + I_2(g) \rightarrow 2HI(g)$
C. $H_2(g) + S(s) \rightarrow H_2S(g)$
D. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

20. Which of the following are the products of electrolysis of a concentrated copper(II) chloride solution using carbon electrode?

	Product at cathode	Product at anode
A.	Hydrogen gas	Chlorine gas
B.	Hydrogen gas	Oxygen gas
C.	Copper	Chlorine gas
D.	Copper	Oxygen gas

21. The oxidizing power of five different metal ions are arranged in the following order:

$$Rb^{+} < Eu^{2+} < Y^{3+} < U^{3+} < Zn^{2+}$$

Which of the following statement is CORRECT?

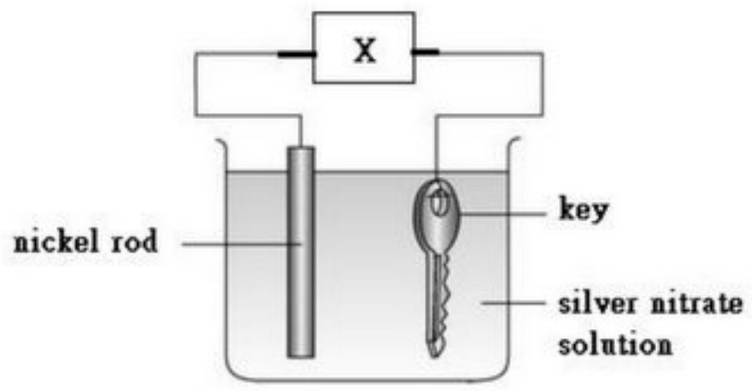
A. When metallic Eu is added to a solution containing Rb^{+} solution, displacement reaction occurs.

B. Metallic Rb is the strongest oxidizing agent.

C. Metallic Y is the most reactive metal among five species.

D. Eu^{2+} is a stronger reducing agent than U^{3+}.

22. A key is undergoing electroplating by using the following set-up.



Which of the following statement is CORRECT?

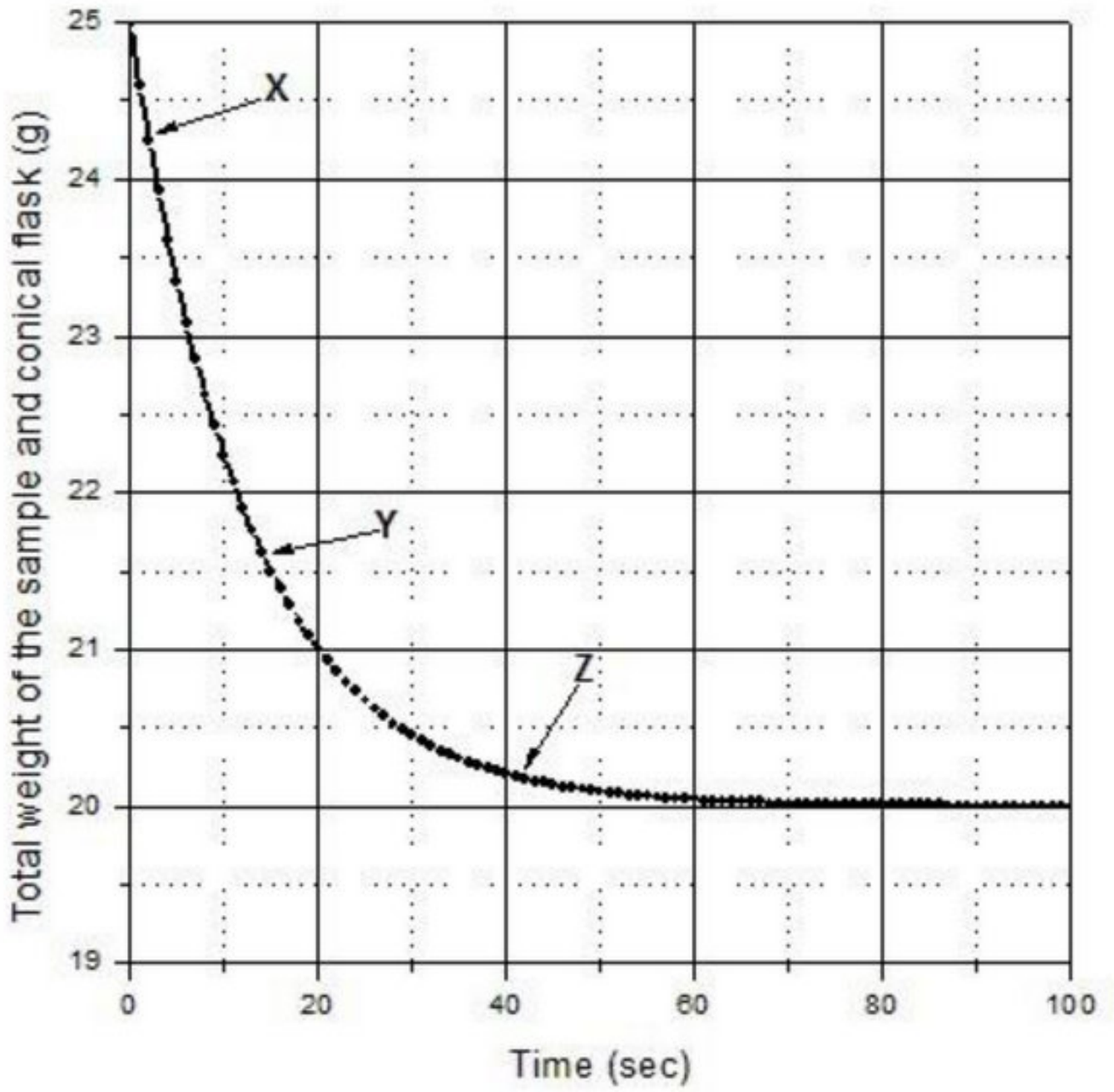
A. X is a voltmeter

B. The concentration of silver ions decreases after the reaction.

C. Nickel is the only metal coated on the key after the electroplating process.

D. Oxygen bubbles are formed on the surface of the key.

23. A sample of 15.0 g sodium bicarbonate ($NaHCO_3$) with inert impurities was added to a conical flask containing an excess amount of dilute hydrochloric acid. The total weight of the solution together with the conical flask was plotted against time (see below).



Compare the rates of the reaction at points **X**, **Y** and **Z**. Arrange the rates in ascending order.

A. Y<Z<X

B. X<Y<Z

C. Y<X<Z

D. Z<Y<X

24. From the above diagram, what is the purity of sodium bicarbonate used in the reaction?

A. 75%

B. 64%

C. 33%

D. 95%

25. Ammonia is produced by the Haber process:

$$N_2\,(g) + 3H_2\,(g) \rightarrow 2NH_3\,(g)$$

The same amounts of H_2 and N_2 are mixed within a closed reaction chamber, and the equilibrium compositions at different temperatures were examined. The equilibrium constant, K_c, for the reaction is 3.36×10^8 at room temperature. At 720°C, the K_c of the reaction is 2.37×10^{-3}. Which of the following is INCORRECT?

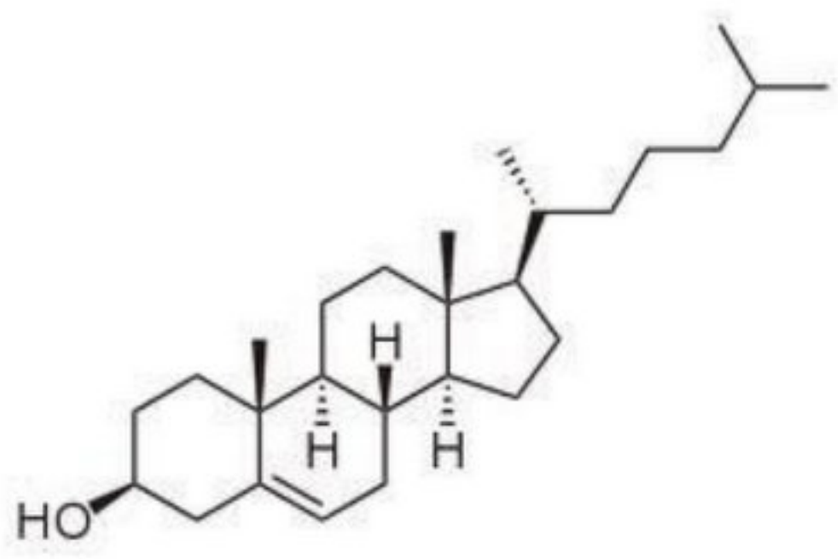
A. The reaction is endothermic.

B. At equilibrium, the total number of mole of gases is smaller at 25°C.

C. There are more ammonia in the chamber at 25°C.

D. The gas pressure inside the chamber is higher at 720°C than 25°C.

26. Cholesterol is a major component of gallstones, and it is believed that cholesterol level in the blood is a contributing factor in certain types of heart disease.



Which statement below regarding the properties of cholesterol is INCORRECT?

A. it can be oxidized by acidified $Na_2Cr_2O_7$ solution.

B. It reacts with bromine under sunlight.

C. It decolorizes bromine in CCl_4 in the dark.

D. It reacts with an amine to form an amide.

27. Which of the following molecules DOES NOT react with $LiAlH_4$?

A. CH_3OCH_3

B. CH_3CHO

C. CH_3CO_2H

D. CH_3COCH_3

28. Which of the following are the uses of the products from electrolysis of brine?

(1) sterilization of drinking water
(2) manufacture of sulphuric acid
(3) manufacture of soap

A. (1) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

29. Which of the following substances will be formed when carbon dioxide is continuously bubbled into lime water?

(1) water
(2) calcium carbonate
(3) calcium hydrogencarbonate

A. (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

30. Element P has 13 protons and element Q has 8 protons. When they combine together, which of the following formula and bonding is correct?

	Formula	**Types of bonding**
A	P_3Q_2	Ionic bond
B	P_3Q_2	Covalent bond
C	P_2Q_3	Ionic bond
D	P_2Q_3	Covalent bond

31. Which of the following statement about diamond and graphite is/are correct?

(1) They are giant covalent structure.
(2) They have van de Waals' force.
(3) Both are elemental forms of carbon

A. (1) only
B. (1) and (2) only
C. (1) and (3) only
D. (2) and (3) only

32. Which of the following metal oxides cannot be reduced by heating with carbon?

(1) Al_2O_3
(2) HgO
(3) PbO

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

33. When metallic zinc is dropped into a beaker of copper(II) sulphate solution, which of the following will be observed?

(1) The blue solution fades in color.
(2) Some colorless gas bubbles are evolved.
(3) Some reddish brown solids are formed on the zinc surface.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

34. Which of the following is/are greenhouse gas(es)?

(1) Methane
(2) Chlorine gas
(3) Nitrogen dioxide

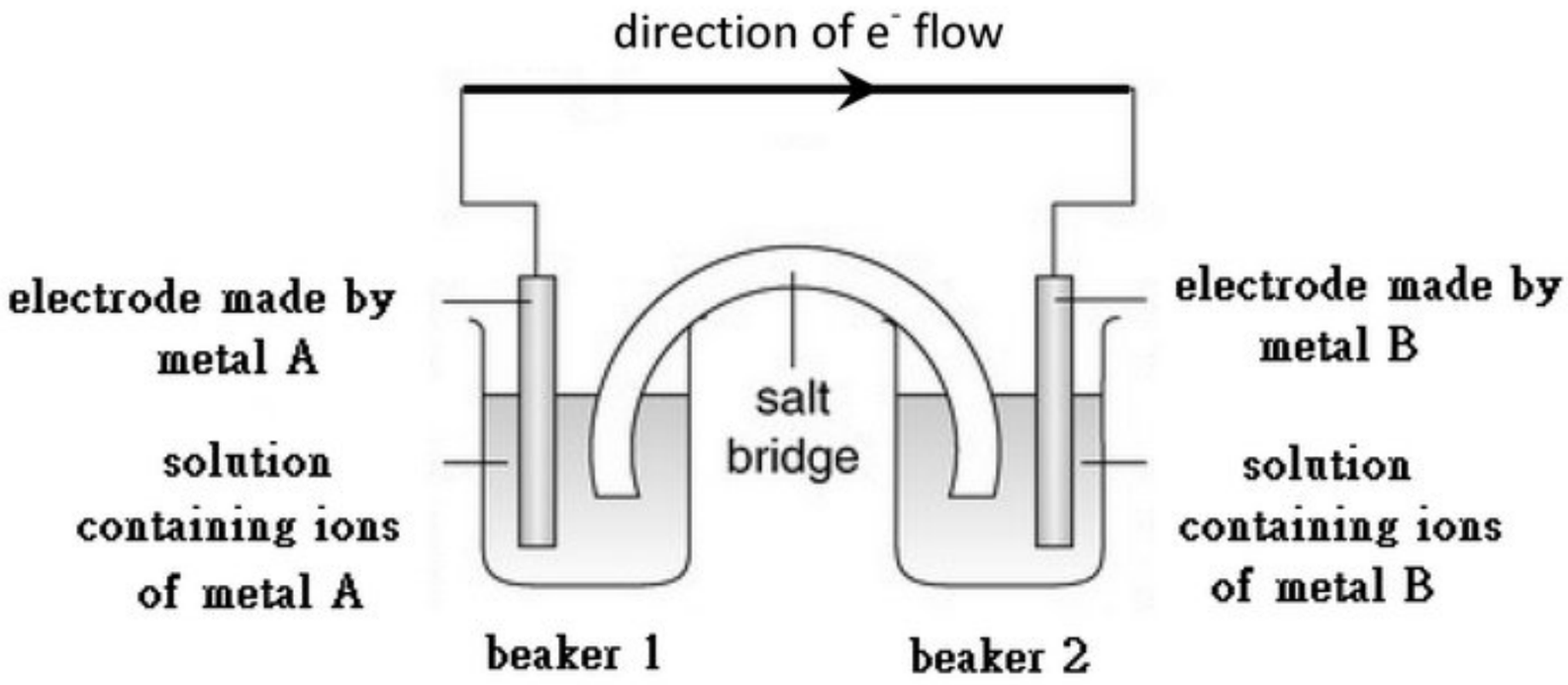
A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

35. Which of the following statement about the reaction between methane and bromine is/are CORRECT?

(1) The reaction is a substitution reaction.
(2) The reaction will be faster in the dark than under sunlight.
(3) The reaction produces a single product only.

A. (1) only
B. (3) only
C. (1) and (3) only
D. (2) and (3) only

36. In the following diagram, A and B are two different metals.



Which of the following statement(s) about the electrochemical cell is/are CORRECT?

(1) The concentration of metal ion in beaker 1 is greater than that in beaker 2.
(2) The reactivity of metal A is higher than that of metal B.
(3) Metal A is the cathode and Metal B is the anode.

A. (1) only
B. (2) only
C. (1) and (2) only
D. (2) and (3) only

37. Which of the following is/are the common chemical waste(s) of the electroplating industry?

(1) Cyanides
(2) Heavy metal ions
(3) Mercury

A. (1) only
B. (2) only
C. (1) and (2) only
D. (1) and (3) only

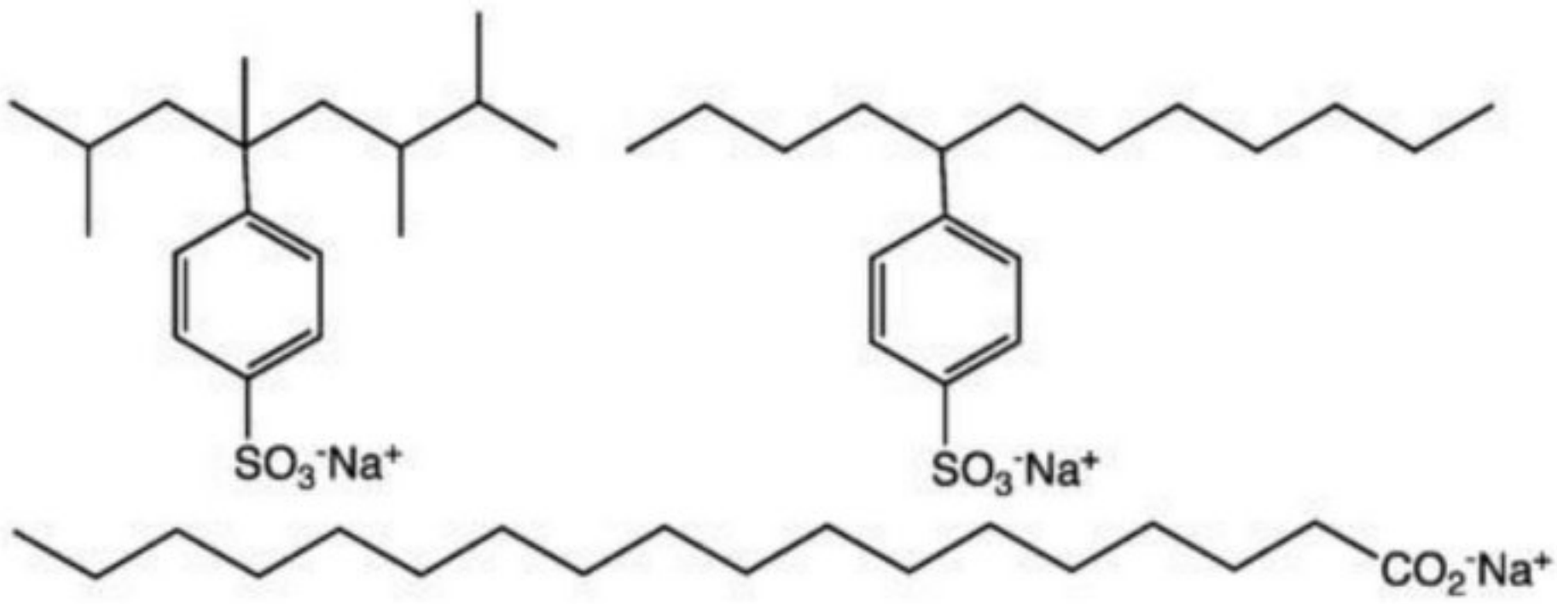
38. Which of the following statement(s) is/are required to determine the standard enthalpy change of the following reaction?

$$2S\ (s) + 3O_2\ (g) \rightarrow 2SO_3\ (g)$$

(1) Standard enthalpy change of formation of sulphur dioxide.
(2) Standard enthalpy change of formation of sulphur.
(3) Standard enthalpy change of formation of oxygen gas.
(4) Standard enthalpy change of vapourization of sulphur to sulphur gas.
(5) Standard enthalpy change of reaction of the oxidation of sulphur dioxide to sulphur trioxide.

A. (1), (2) and (3) only
B. (5) only
C. (1) and (5) only
D. All of the above

39. Consider the following compounds,

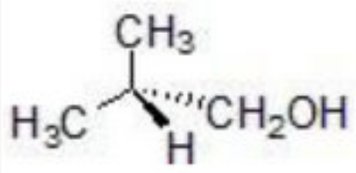
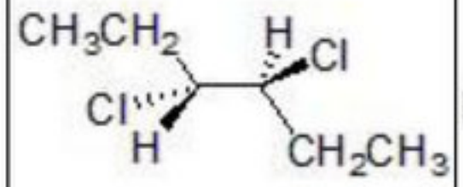
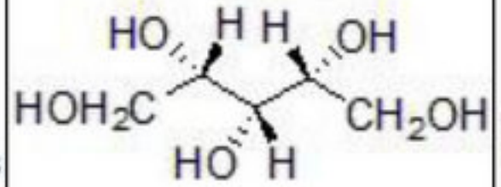
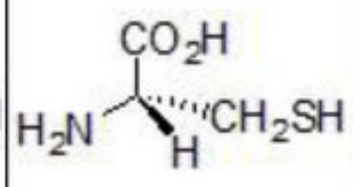
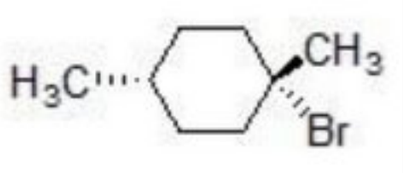


Which of the following statements below are INCORRECT?

(1) They are soluble in hydrocarbon solvents
(2) They have higher melting points than crystalline NaCl
(3) They dissolve in water to give a pH neutral solution
(4) They can be used as detergent

A. (3) and (4) only
B. (2) and (3) only
C. (1) and (2) only
D. (1) and (3) only

40. Which of the following compounds are achiral?

				
1	**2**	**3**	**4**	**5**

A. (1), (2) and (5) only

B. (2), (3) and (4) only

C. (1), (3) and (5) only

D. (3), (4) and (5) only

End of Section A

Section B: Short Questions (20 marks)

Answer any FIVE questions.

1. A student performs some tests on an unknown compound X and obtains the following results.

   (i) It is soluble in water.
   (ii) It is a white powder at room temperature and pressure.
   (iii) It does not show any characteristic colours during a flame test.
   (iv) Heating X gives a colourless gas W, which turns red litmus paper to blue.
   (v) Adding excess dilute nitric acid and silver nitrate solution to compound X, a white precipitate is formed.

   (a) From tests (iii) and (iv), what can be the cation of compound X? Explain your answer. (2 marks)

   (b) From test (v), what can be the anion of compound X? Explain with an appropriate equation.

   (2 marks)

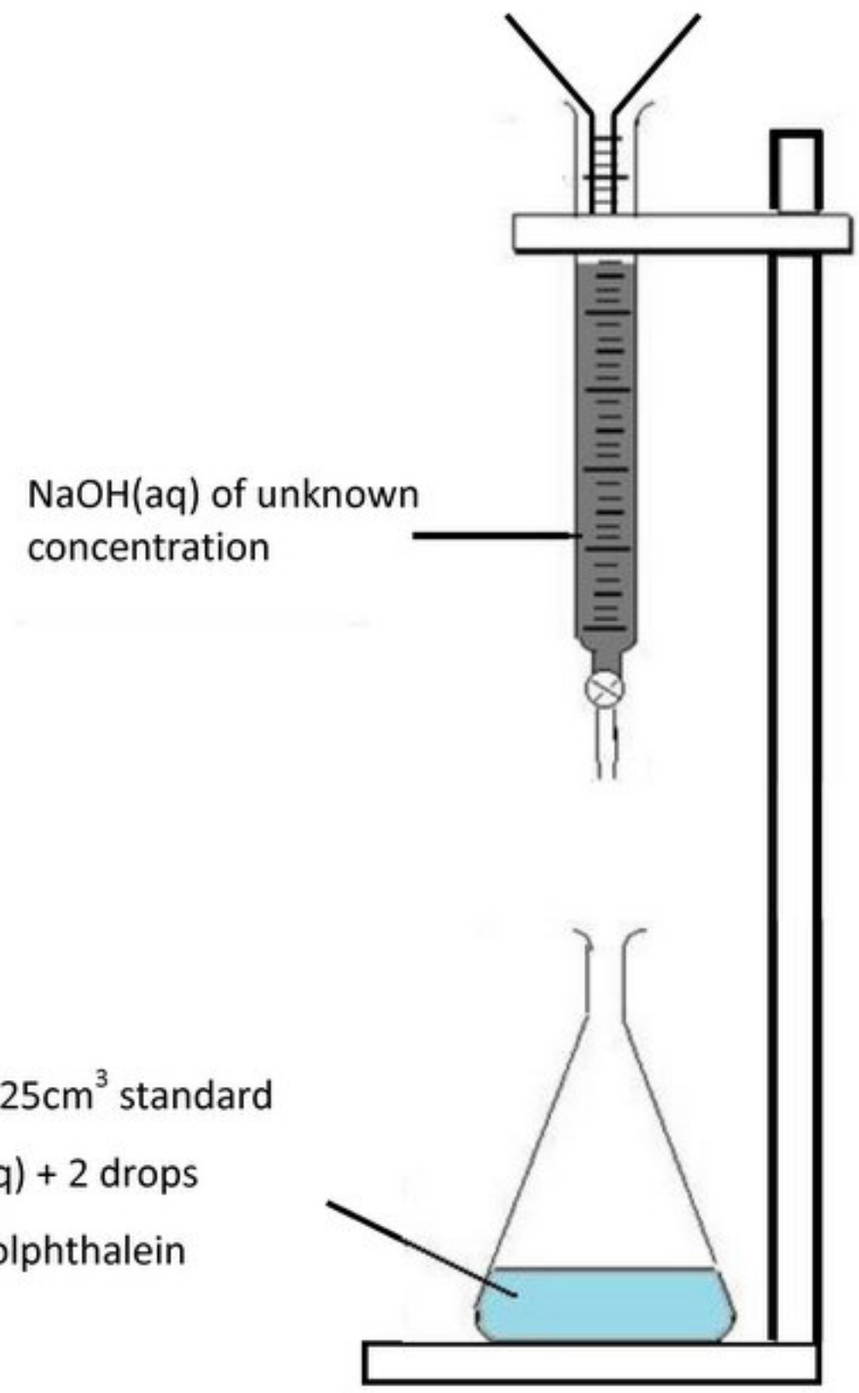
2. Hydrogen peroxide (H_2O_2) can be decomposed into water and oxygen gas. This reaction is a redox reaction.

   (a) Write down the half equation for hydrogen peroxide decomposing to water. (1 mark)

   (b) Write down the half equation for hydrogen peroxide decomposing to oxygen gas. (1 mark)

   (c) Which process, (a) or (b), is an oxidation reaction? Give an explanation. (2 marks)

3. Student A uses the following set-up for titration of sodium hydroxide solution with a standard hydrochloric acid solution:



State and explain TWO possible improvements in this set-up. (4 marks)
e.g. The tip of burette should be located within the conical flask and closer to the solution

4. The following is a series of reactions starting from compound P:

$$P \xrightarrow{\text{conc. } H_2SO_4} \text{ethanol} \xrightarrow{\text{reagent A}} Q \xrightarrow{NaHCO_3(aq)} CO_2(g) + R$$

(a) Write down the names of A, Q and R. (3 marks)

(b) Draw the molecular structure of P. (1 mark)

5. Calculate the pH of a 2.10 x 10^{-3} M NaCN solution. When dissolved in water, the cyanide anion could undergo hydrolysis to form HCN. The equilibrium constant, K_c, of this process is 2.04 x 10^{-5}.

$$CN^-(aq) + H_2O(l) \rightleftharpoons HCN(aq) + OH^-(aq)$$

(4 marks)

6. In an experiment to determine the enthalpy change of a neutralization reaction, a solution of 12.0 cm^3 of 6.00 M HCl at 21.3 °C is mixed with 300 cm^3 of 0.25 M NaOH, also at 21.3 °C. The enthalpy change of this reaction is -56.1 $kJmol^{-1}$. Assuming that there is no heat loss to the container, the specific heat capacity of the final solution is 4.18 $kJkg^{-1}K^{-1}$, and the density of the final solution is 1.00 gcm^{-3}. What is the temperature of the resulting solution?

(4 marks)

END OF PAPER