

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD  
UNIVERSITY OF MALTA, MSIDA  
MATRICULATION CERTIFICATE EXAMINATION  
INTERMEDIATE LEVEL  
MAY 2012

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<b>SUBJECT:</b>	CHEMISTRY
<b>DATE:</b>	3rd May 2012
<b>TIME:</b>	9.00 a.m. to 12.00 noon

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*Useful information:* One mol of any gas or vapour occupies  $22.4 \text{ dm}^3$  at s.t.p.

The molar gas constant  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ .

Relative atomic masses: H = 1, He = 4, O = 16, C = 12, Na = 23, Fe = 56, Mn = 55; Cl = 35.5.

The ionization constant of water is  $1 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ .

The Avogadro Constant is  $6 \times 10^{23}$ .

**A Periodic Table is included.**

*Section A*

**Answer all questions in this Section**

1. Give the name of:

- a) the allotrope of carbon which conducts electricity \_\_\_\_\_
- b) The type of bonding present in solid iron \_\_\_\_\_
- c) The process that occurs when solid iodine changes directly to a vapour \_\_\_\_\_
- d) the first member of the homologous series of alcohols \_\_\_\_\_
- e) the type of structure formed by silicon dioxide \_\_\_\_\_

*(5 marks)*

2. Hydrogen can be produced in the laboratory in a number of ways. Write balanced equations to represent the formation of hydrogen by the reaction of:

- a) a metal with water;

\_\_\_\_\_

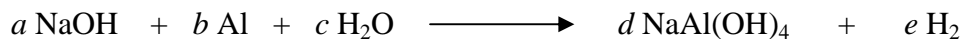
b) a metal with dilute sulfuric acid; and

\_\_\_\_\_

c) sodium hydride with water.

*(6 marks)*

3. Hydrogen can also be produced by the reaction of aluminium with hot aqueous sodium hydroxide. Find the values of  $a$ ,  $b$ ,  $c$ ,  $d$  and  $e$  in the following equation:



$$a = \underline{\hspace{2cm}} \quad b = \underline{\hspace{2cm}} \quad c = \underline{\hspace{2cm}} \quad d = \underline{\hspace{2cm}} \quad e = \underline{\hspace{2cm}} \quad (2 \text{ marks})$$

4. Give the systematic names of the following organic compounds:

$\text{CH}_3\text{CH}_2\text{NH}_2$  \_\_\_\_\_

$\text{CH}_3\text{CHClCH}_2\text{Cl}$  \_\_\_\_\_

$\text{CH}_3\text{CH}_2\text{CHCl}_2$  \_\_\_\_\_

$\text{CH}_3\text{CHBrCH}_2\text{Cl}$  \_\_\_\_\_ (8 marks)

5. a) Define the term *pH of a solution*.

\_\_\_\_\_ (2 marks)

- b) From the following list:

$0.100 \text{ mol dm}^{-3} \text{ HCl}$ ;  $1.00 \text{ mol dm}^{-3} \text{ HNO}_3$ ;  $1.00 \text{ mol dm}^{-3} \text{ H}_2\text{SO}_4$ ;

$1.00 \text{ mol dm}^{-3} \text{ KOH}$ ;  $0.100 \text{ mol dm}^{-3} \text{ NaOH}$

select:

i) the solution with the highest pH value \_\_\_\_\_

ii) the solution with the lowest pH value \_\_\_\_\_

(4 marks)

6. The pH of pure water is 7. State whether the pH would increase, decrease or remain the same when the following substances are dissolved in the water:

i) sodium chloride crystals \_\_\_\_\_

ii) carbon dioxide \_\_\_\_\_

iii) ammonia \_\_\_\_\_

iv) sulfur dioxide \_\_\_\_\_

v) sugar \_\_\_\_\_

(5 marks)

7. a) Define the term *electronegativity*.

\_\_\_\_\_  
\_\_\_\_\_  
(2 marks)

b) The following is a list of some elements and their electronegativities:

K: 0.8 Na: 0.9 Mg: 1.2 Cl: 3.0 F: 4.0

Use this list to arrange the following compounds in order of increasing ionic character *starting with the least ionic*:

KCl NaCl NaF MgCl<sub>2</sub> KF

\_\_\_\_\_  
(5 marks)

8. A rapid reaction takes place when powdered calcium carbonate is added to 200 cm<sup>3</sup> of a solution of hydrochloric acid of concentration 1.00 mol dm<sup>-3</sup> at 30 °C. Which of the following changes in the above procedure will cause a *slower* reaction?

*Place a tick mark next to each correct answer.*

a) Using large pieces of calcium carbonate instead of the powdered solid. \_\_\_\_\_

b) Using nitric acid of the same concentration instead of hydrochloric acid. \_\_\_\_\_

c) Carrying out the reaction at 20°C instead of at 30 °C. \_\_\_\_\_

d) Adding 100 cm<sup>3</sup> of distilled water to the beaker containing the carbonate before adding the acid. \_\_\_\_\_

e) Using hydrochloric acid of concentration 2.0 mol dm<sup>-3</sup>. \_\_\_\_\_

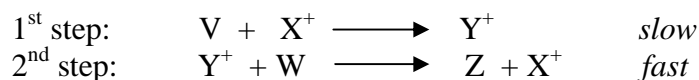
(5 marks)

9. The reaction  $V + W \longrightarrow Z$  is endothermic.

- a) Draw, in the space below, an energy profile for the reaction showing clearly  $\Delta H$  and the activation energy  $E_A$  and label clearly both axes.

(4 marks)

- b) When  $X^+$  ions are added to the reaction mixture, the reaction takes place in the following way:



- i) Why is the first step of this reaction the rate determining step?

(2 marks)

- ii) What feature shows that  $X^+$  ions are catalyzing the reaction?

(2 marks)

10. In the following list underline the substances in which only van der Waals forces operate as interactions between molecules:



11. a) An organic compound **H** contains 40.0% carbon, 6.67% hydrogen and 53.3% oxygen by mass. What is the empirical formula of **H**?

(3 marks)

- b) The mass spectrum of **H** gave a peak with mass to charge ( $m/z$ ) ratio equal to 90 and there were no peaks of higher  $m/z$  ratio. What is the molecular formula of **H**.

(2 marks)

12. Which one of the following amounts of helium contains the greatest number of He atoms? Show the calculations.

- a) 2 moles    b) 12.0 g    c) 30.0 dm<sup>3</sup> measured at s.t.p.

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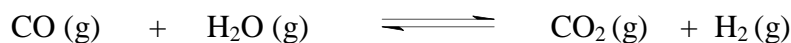
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\_\_\_\_\_ (3 marks)

13. Consider the following reaction:



- a) Write an expression for the equilibrium constant  $K_c$  for the above reaction and state the units *if any*.

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\_\_\_\_\_ (2 marks)

- b) An increase in temperature will shift the position of equilibrium to the right. Deduce whether the forward reaction is exothermic or endothermic.

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\_\_\_\_\_ (1 mark)

14. a) Give the full (s,p,d...) electron configuration of manganese, Mn (atomic number 25).

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\_\_\_\_\_ (2 marks)

- b) Manganese is a typical transition metal. List three important properties that one would expect manganese and/or its compounds to have.

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\_\_\_\_\_ (3 marks)

15. a) Draw structural formulae, showing all the bonds for the following compounds:

butan-2-ol      2-methylpropan-1-ol      2-methylpropan-2-ol

(6 marks)

b) Which of the alcohols is:

primary \_\_\_\_\_ secondary \_\_\_\_\_

tertiary \_\_\_\_\_

(3 marks)

### Section B

#### Answer all questions in this Section

16. a) State the colour changes that occur in the following procedures:

i) Chlorine gas is bubbled through potassium iodide solution. The colour of the solution changes from \_\_\_\_\_ to \_\_\_\_\_ .

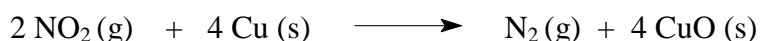
ii) Sulfur dioxide gas is bubbled through potassium dichromate solution acidified with sulfuric acid. The colour of the solution changes from \_\_\_\_\_ to \_\_\_\_\_ .

iii) A few drops of water are added to anhydrous copper(II) sulfate. The colour of the solid changes from \_\_\_\_\_ to \_\_\_\_\_ .

iv) A piece of magnesium ribbon is placed in copper(II) sulfate solution. The colour of the solution changes from \_\_\_\_\_ to \_\_\_\_\_ .

(8 marks)

b) When the following reaction takes place:



The colour of the solid changes from \_\_\_\_\_ to \_\_\_\_\_

and the colour of the gas changes from \_\_\_\_\_ to \_\_\_\_\_ .

(4 marks)

c) What colours are obtained when the following substances are tested by heating in a flame? If any substance does not give a colour state so clearly.

i) sodium chloride \_\_\_\_\_

ii) potassium nitrate \_\_\_\_\_

iii) calcium chloride \_\_\_\_\_

iv) magnesium chloride \_\_\_\_\_

(4 marks)

(Total: 16 marks)

17. a) Give the structural formula of the organic product obtained when propan-1-ol,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$  reacts with:

i) sodium

ii) phosphorus pentachloride

iii) concentrated sulfuric acid at  $180^\circ\text{C}$

iv) concentrated sulfuric acid at  $140^\circ\text{C}$

v) propanoic acid in the presence of some concentrated sulfuric acid

(10 marks)

b) Give the systematic names of the products of:

reaction (ii) \_\_\_\_\_

reaction (iii) \_\_\_\_\_

reaction (v) \_\_\_\_\_

(3 marks)

c) State the reagents and reaction conditions required to produce propanoic acid from propan-1-ol.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (3 marks)

(Total: 16 marks)

18. a) Ammonia is a polar covalent molecule.

i) Explain why the molecule is polar.

\_\_\_\_\_ (1 mark)

ii) Draw the structure of the ammonia molecule and, using  $\delta +$  and  $\delta -$  as appropriate, indicate the partial charges on each atom of the molecule.

\_\_\_\_\_ (2 marks)

iii) Draw a diagram showing clearly the shape of the ammonia molecule.

\_\_\_\_\_ (3 marks)

iv) Why is the bond angle in ammonia  $107^\circ$  rather than  $109.5^\circ$ ?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (2 marks)

b) Ammonia gas is produced when a solution of ammonium chloride is heated with aqueous sodium hydroxide.

i) Write a balanced equation, including state symbols, for the reaction that takes place.

\_\_\_\_\_ (3 marks)

ii) Write an ionic equation omitting spectator ions for this reaction.

\_\_\_\_\_ (3 marks)

c) Give the formula of a complex ion which contains ammonia molecules as ligands.

\_\_\_\_\_ (2 marks)

(Total: 16 marks)



19. An atom of an isotope of element X has three more protons and four more neutrons than an atom of  $^{24}\text{Mg}$ .

a) Give the symbol, the mass number and atomic number for atom X.

\_\_\_\_\_ (3 marks)

b) Using the s,p,d notation give the electron configuration of:

Mg \_\_\_\_\_

X \_\_\_\_\_ (2 marks)

c) What is the difference between isotopes of the same element?

\_\_\_\_\_ (2 marks)

d) The element Y is in the same Period of the Periodic Table as Mg and X. The first seven successive ionization energies of Y in  $\text{kJ mol}^{-1}$  are:

789    1580    3230    4360    16100    19800    23800

i) Give the symbol of the element Y and the Group of the Periodic Table to which it belongs. Explain your answer.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (4 marks)

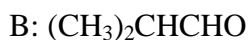
ii) Define the term first ionization energy.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (3 marks)

iii) Write an equation for the first ionization energy of Y.

\_\_\_\_\_ (2 marks)  
(Total: 16 marks)

20. This question concerns the four organic compounds labelled A, B, C and D whose structural formulae are:



a) State the relationship between these four compounds.

\_\_\_\_\_ (2 marks)

b) Give the systematic names of:

A: \_\_\_\_\_

B: \_\_\_\_\_

C: \_\_\_\_\_

(3 marks)

c) Which of the above four compounds has the highest boiling point? Explain your answer.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (3 marks)

d) From the above four compounds select the compound/s which react/s with Fehling's solution to produce a red-brown precipitate.

\_\_\_\_\_ (2 marks)

e) Give the structural formula of the product of the reaction of compound D with:

i) HI

ii) hydrogen in the presence of heated Ni

iii) bromine

(6 marks)  
(Total: 16 marks)

**Section C**  
**Answer TWO questions from this Section**

21. Hydrogen peroxide decomposes as follows:



- a) Explain why this reaction is a disproportionation reaction. (3 marks)
- b) Describe fully how you would test for oxygen gas. (4 marks)
- c) Calculate the volume of oxygen that is produced when all the hydrogen peroxide present in  $400 \text{ cm}^3$  of a solution of concentration  $0.100 \text{ mol dm}^{-3}$  decomposes. The oxygen produced is collected at  $37^\circ \text{C}$  and  $100 \text{ kPa}$  pressure. Give your answer to the nearest  $\text{cm}^3$ . (11 marks)
- d) Sketch, using suitably labelled axes, the number of molecules versus molecular kinetic energies for a fixed amount of oxygen gas at a temperature  $T_1$ . On the same axis sketch the distribution of molecular kinetic energies for the same amount of oxygen gas at a higher temperature  $T_2$ . (5 marks)
- e) The reaction is catalysed by manganese dioxide. Explain clearly the meaning of the term catalyst. (3 marks)
- f) Manganese dioxide can also act as an oxidizing agent and oxidizes hydrochloric acid to chlorine according to the following equation:



- i) Balance the above equation by finding the values of a, b, and c and explain carefully why this reaction is a redox reaction indicating clearly what is being oxidized and what is being reduced. (6 marks)
- ii) Calculate the volume of chlorine, measured at s.t.p., that is obtained from the reaction of  $1.74 \text{ g}$  of manganese dioxide with excess hydrochloric acid. Calculate also the mass of  $\text{MnCl}_2$  produced. (8 marks)

(Total: 40 marks)

22. A student prepared a solution by weighing accurately  $9.70 \text{ g}$  of sulfamic acid, molecular formula  $\text{H}_3\text{NSO}_3$ , and making up the solution to  $250 \text{ cm}^3$  with distilled water in a conical flask.

- a) Calculate the concentration of the sulfamic acid solution in  $\text{mol dm}^{-3}$ . (4 marks)
- b) Sulfamic acid is a monobasic (monoprotic) acid, that is, it releases one  $\text{H}^+$  ion per molecule. Write an equation for the reaction of sulfamic acid with sodium carbonate. (4 marks)

- c) In a titration,  $25.00 \text{ cm}^3$  of the sulfamic acid solution reacted exactly with  $20.0 \text{ cm}^3$  of a solution of sodium carbonate. Calculate the concentration of the sodium carbonate solution in  $\text{mol dm}^{-3}$ . (12 marks)
- d) The sodium carbonate solution was prepared by dissolving 35.75 g of hydrated sodium carbonate crystals and making up the solution to  $500 \text{ cm}^3$  with distilled water. Calculate the value of 'x' in the formula of hydrated sodium carbonate  $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$ . (12 marks)
- e) Sulfamic acid is a strong acid. Explain the meaning of the term *strong acid* and give the name and formula of:
- i) another strong acid;
  - ii) a weak acid;
  - iii) a strong base; and
  - iv) a weak base.
- (8 marks)  
(Total: 40 marks)
23. Explain each of the following statements as fully as you can giving structural formulae and equations as appropriate.
- a) There are three structural isomers of molecular formula  $\text{C}_4\text{H}_8$  which decolourise aqueous bromine. One of these structural isomers exists as a pair of geometrical isomers. Another structural isomer of molecular formula  $\text{C}_4\text{H}_8$  has no visible effect on aqueous bromine. (18 marks)
- b) Both solid sodium chloride and wax (which can be considered as an alkane of molecular formula  $\text{C}_{16}\text{H}_{34}$ ) are non-conductors of electricity. When heated both substances melt but wax melts at a much lower temperature than sodium chloride. Molten sodium chloride is a good conductor of electricity but molten wax is a non-conductor. (12 marks)
- c) Methane and chlorine do not react if they are kept in darkness; however they react rapidly when exposed to light to give a mixture of organic compounds and hydrogen chloride. (10 marks)  
(Total: 40 marks)
24. When calcium oxide is strongly heated with carbon in the absence of air, calcium carbide and carbon monoxide are produced. Calcium carbide reacts with water to produce calcium hydroxide and ethyne.
- a) Write balanced equations for the above reactions and explain why the reaction between calcium oxide and carbon has to be carried out in the absence of air. (8 marks)

















