

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD
UNIVERSITY OF MALTA, MSIDA

MATRICULATION CERTIFICATE EXAMINATION
INTERMEDIATE LEVEL
SEPTEMBER 2012

SUBJECT: CHEMISTRY
DATE: 10th September 2012
TIME: 9.00 a.m. to 12.00 noon

Useful information: One mol of any gas or vapour occupies 22.4 dm^3 at s.t.p. The molar gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$. Relative atomic masses: H = 1.0, O = 16, C = 12, Al = 27, Na = 23, N = 14, Fe = 56, S = 32; Cl = 35.5, Sn = 119. The ionization constant of water is $1 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$. A Periodic Table is included.

Section A
Answer ALL questions in this Section

1. Give the name and formula/symbol of:

an acidic gas _____

a basic gas _____

a gas that relights a glowing splint _____

a gas that burns with a pop when ignited _____

an inert gas _____

(5 marks)

2. From the following list of separation techniques:

chromatography, distillation, crystallisation, sublimation, filtration,

select the method that could be used to:

a) separate a mixture of sand and water _____

b) obtain water from sea water _____

c) obtain ammonium chloride from a mixture of ammonium chloride and sodium chloride _____

d) separate a mixture of inks _____

e) obtain $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ from aqueous magnesium sulfate _____

(5 marks)

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3. Give the name and structural formula of:

a) the third member of the homologous series of alkanes;

b) the isomer of molecular formula C_5H_{12} which has the lowest boiling point;

c) a cycloalkane of molecular formula C_5H_{10} ;

d) the two isomers of molecular formula $C_2H_4Cl_2$.

_____ (10 marks)

4. Describe clearly the bonding present in the element aluminium.

_____ (3 marks)

5. a) Draw dot and cross diagrams, showing only the outer electrons of the following molecules:



(4 marks)

b) Explain why BF_3 is electron deficient.

_____ (2 marks)

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6. a) From the following list:



select the molecule(s) for which the strongest intermolecular forces are best described as:

van der Waals forces _____

permanent dipole-permanent dipole attractions: _____

hydrogen bonding _____ (7 marks)

b) Name two substances which are macromolecular (giant covalent):

_____ (2 marks)

7. Ethanoic acid reacts reversibly with methanol to produce the ester methyl ethanoate and water.

i) Write a balanced equation for this reaction.

_____ (3 marks)

ii) Name the reagent that is used to catalyse this reaction.

_____ (2 marks)

8. Draw the structure of the repeating unit of the polymer formed by

i) ethene

ii) propene

(6 marks)

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9. From the following list of elements:

sodium, aluminium, carbon, phosphorus, sulfur,

select:

a) the element which forms a hydride of formula H_2X _____

b) the element which forms two chlorides of formulae MCl_3 and MCl_5 _____

c) the element whose first six successive ionization energies are:

1090 2400 4600 6200 37800 47300 _____

d) the element which forms an amphoteric oxide _____

e) the element which reacts with cold water _____

(5 marks)

10. List three advantages for using hydrogen as a fuel.

_____ (3 marks)

11. Mention three ways by which the rate of a chemical reaction can be increased.

_____ (3 marks)

12. The mass spectrum of ethanoic acid CH_3CO_2H shows peaks at m/z ratios 15, 43, 45 and 60. Write the molecular formulae for the fragment ions responsible for these peaks.

15 _____ 43 _____ 45 _____ 60 _____ (4 marks)

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13. a) In the following reaction:



name or give the formula of:

i) the species on the left hand side that is acting as an acid: _____

ii) its conjugate base on the right hand side: _____

iii) the species on the left hand side that is acting as a base: _____

iv) its conjugate acid on the right hand side: _____

(4 marks)

b) What is the pH of the following solutions?

0.0100 mol dm⁻³ HCl: _____

0.0100 mol dm⁻³ NaOH _____

(3 marks)

14. Write equations to represent:

a) the standard enthalpy change of formation of methane.

b) the standard enthalpy change of combustion of hydrogen.

_____ (6 marks)

15. Complete the following statements by writing the appropriate information in the spaces provided:

In an aqueous solution of sugar, the solvent is _____ and the solute is _____.
 This solution does not conduct electricity because _____.

(3 marks)

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Section B
Answer ALL questions in this Section

16. a) The atomic number of chlorine is 17. Define the term atomic number.

_____ (2 marks)

b) Complete the following electronic configurations:

Cl: $1s^2$ _____

Cl^- $1s^2$ _____ (2 marks)

c) chlorine exists as two isotopes of mass numbers 35 and 37 respectively. Define the terms:

mass number _____

isotopes _____

_____ (4 marks)

d) Arrange the following in order of increasing oxidizing power starting with the weakest:

chlorine; iodine; bromine.

_____ (3 marks)

e) Mention two uses of chlorine.

_____ (2 marks)

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- f) Hydrogen chloride can be prepared by the action of hot concentrated sulfuric acid on sodium chloride. The equation for the reaction is:



Calculate the volume of hydrogen chloride, measured at s.t.p., that is produced by the action of excess concentrated sulfuric acid on 11.70 g of sodium chloride.

(3 marks)

(Total: 16 marks)

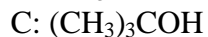
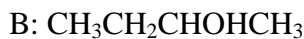
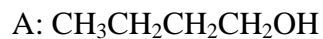
17. Complete the following table by giving the structural formulae and the names of the molecules which correspond to the description given on the left hand side.

The organic product of the reaction of benzene and a hot mixture of concentrated nitric and sulfuric acids.	Structure: Name:
The organic product obtained when sodium propanoate $\text{CH}_3\text{CH}_2\text{CO}_2\text{Na}$ is heated with soda-lime.	Structure: Name:
The geometric isomer of <i>cis</i> -but-2-ene.	Structure: Name:
An isomer of butanal which is NOT an aldehyde.	Structure: Name:
The salt obtained when ethylamine reacts with hydrochloric acid	Structure: Name: <i>not required</i>
The product of the reaction of ethanal and hydrogen cyanide.	Structure: Name: <i>not required</i>

(16 marks)

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18. This question concerns the four compounds labelled A, B, C and D:



a) Give the systematic names of:

A: _____ B: _____

C: _____ (3 marks)

b) i) The four compounds are isomers of each other. What feature makes them isomers?

_____ (2 marks)

ii) Which of the above compounds cannot be oxidized by hot aqueous potassium dichromate and sulfuric acid?

_____ (2 marks)

iii) Give the structural formula of another compound which is an isomer of these four compounds and which is not an alcohol.

_____ (2 marks)

c) Write balanced equations for the reactions of A with:

i) phosphorus pentachloride:

ii) sodium:

_____ (5 marks)

d) Which one(s) of the above compounds can be oxidized to a product which will reduce Fehlings solution?

_____ (2 marks)

(Total: 16 marks)

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19. a) In a titration, 25.0 cm^3 of a solution containing 10.0 g dm^{-3} of a hydrogencarbonate of formula XHCO_3 reacted exactly with 22.50 cm^3 of a solution of nitric acid of concentration $0.111 \text{ mol dm}^{-3}$. Calculate the relative atomic mass of X.

i) Calculate the number of H^+ ions involved in the titration.

(3 marks)

ii) Calculate the number of moles of XHCO_3 reacting with the aquated protons and hence find the number of moles of XHCO_3 dissolved in 1 dm^3 of solution.

(4 marks)

iii) Calculate the relative atomic mass of X.

(3 marks)

b) Give the full electronic configuration of iron, Fe, and the Fe^{2+} ion.

Fe: _____ (1 mark)

Fe^{2+} : _____ (1 mark)

c) A solution of iron(II) sulfate contains the ion $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$. Explain clearly how the water molecules are bonded to the Fe^{2+} ions.

(4 marks)

(Total: 16 marks)

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20. a) Give the oxidation number of manganese, Mn, in the following species:

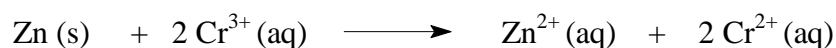


b) Explain clearly why the following is not a redox reaction:



 _____ (3 marks)

c) In the following reaction:



name:

i) the oxidising agent: _____

ii) the reducing agent: _____ (2 marks)

d) Define the term *disproportionation*.

 _____ (3 marks)

e) Complete the following equation by finding the values of *a*, *b* and *c* and explain clearly why this is a disproportionation reaction.



 _____ (4 marks)

(Total: 16 marks)

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Section C
Answer TWO questions from this Section

21. Describe one chemical test in each case by which the following pairs of aqueous solutions can be distinguished. In each case name the reagent(s) used and describe clearly how the test is carried out and its result with both solutions. Equations must be given for all reactions taking place and where no reaction occurs this must be stated clearly.
- sodium chloride and sodium bromide.
 - magnesium sulfate(VI) and aluminium sulfate(VI).
 - sodium carbonate and sodium sulfate(IV).
 - iron (II) sulfate(VI) and iron(III) sulfate(VI).
 - lead(II) nitrate and zinc nitrate. (40 marks)
22. a) A mixture contains 0.800 moles of anhydrous aluminium nitrate and 0.400 moles of anhydrous aluminium sulfate. Calculate (i) the number of moles of aluminium, sulfate and nitrate, respectively, present in the mixture; and (ii) the total mass of the mixture. (10 marks)
- b) Bronze is an alloy made up of 60.0% copper and 40.0% tin by mass. Calculate the number of moles of copper and tin atoms present in 500 g of bronze. (7 marks)
- c) To 50 cm³ of a solution containing 1 g dm⁻³ of silver nitrate are added 50 cm³ of aqueous sodium chloride containing 2 g dm⁻³. Explain what you would observe and calculate the mass of precipitate obtained. (13 marks)
- d) Compound **M** contains 62.1% carbon, 10.3% hydrogen and 27.6% oxygen by mass.
- Find the empirical formula of **M**.
 - When 0.180 g of **M** were vapourised in a gas syringe at 77 °C and 100 kPa, the volume of vapour obtained was 45.1 cm³. Calculate the relative molecular mass of **M** and hence find its molecular formula. (10 marks)

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23. a) Alpha and beta particles and gamma rays may be emitted during radioactive changes.
- Give the main properties of these three types of radiation. Your answer should include their relative mass, charge, approximate range in air, behaviour in electrical and magnetic fields as well as ways by which the radiation may be stopped. *You could answer this part of the question in table form.* (15 marks)
 - Define the term half-life and calculate the amount of the radioactive isotope X which is left after 40 hours from an original sample of mass 10.0 g if the half-life of X is 10 hours. (6 marks)
 - Give two uses of radioisotopes or radioactivity in medicine and two uses in industry. (6 marks)
- b) The following elements are placed in order of their reactivity starting with the most reactive: Mg, Fe, Cu, Ag. Rewrite the series and include the following elements in their appropriate place in the series: Zn, Na, H, K. (4 marks)
- c) Write ionic equations, including state symbols and omitting spectator ions, for the reactions that take place when:
- magnesium is added to dilute sulfuric acid;
 - magnesium is added to silver nitrate solution;
 - iron is added to copper(II) sulfate solution. (9 marks)

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24. a) Ethene reacts with hydrogen bromide to form bromoethane.

i) Give the mechanism of the reaction. (10 marks)

ii) Calculate the enthalpy change, in kJ mol^{-1} , for the reaction between ethene and hydrogen bromide. The following bond enthalpies, in kJ mol^{-1} are required for the calculation:

H-Br: 366 C-Br: 280 C=C: 610 C-C: 346 C-H: 415 (8 marks)

iii) Would you expect the value for the enthalpy change for the reaction between propene and hydrogen bromide to be the same or different from the value obtained in part (ii). Explain your answer. (3 marks)

iv) Give the name and structural formula of the product obtained from the reaction of propene and hydrogen bromide. (3 marks)

b) When propane is heated to $700\text{ }^{\circ}\text{C}$ in a sealed container in the absence of air the following equilibrium is set up:



State the name given to the forward reaction of this reversible change and explain what happens to the position of the equilibrium if (i) the temperature is increased and (ii) the pressure is increased.

(8 marks)

c) The equilibrium mixture obtained in part (b) was found to contain 1.50 moles of C_3H_8 and 1.20 moles each of C_2H_4 and CH_4 in a container of volume 10 dm^3 . Write an expression for the equilibrium constant, K_c , calculate its value and state the units.

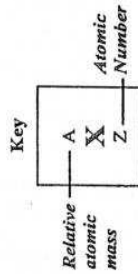
(8 marks)

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PERIODIC TABLE

III	IV	V	VI	VII	VIII
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11	12	14	16	19	20
B	C	N	O	F	Ne
5	6	7	8	9	10
27	28	31	32	35.5	40
Al	Si	P	S	Cl	Ar
13	14	15	16	17	18
70	73	75	79	80	84
Ga	Ge	As	Se	Br	Kr
31	32	33	34	35	36
115	119	122	128	127	131
In	Sn	Sb	Te	I	Xe
49	50	51	52	53	54
204	207	209	209	210	222
Tl	Pb	Bi	Po	At	Rn
81	82	83	84	85	86



I	II
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1	9
H	Be
1	4
Li	B
3	5
23	24
Na	Mg
11	12
39	40
K	Ca
19	20
85	88
Rb	Sr
37	38
133	137
Cs	Ba
55	56
223	226
Fr	Ra
87	88