Level 3 International Foundation Diploma for Higher Education Studies
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Chemistry for University Study

SAMPLE EXAMINATION

This specimen assessment material is devised from previous past papers to reflect the single examination assessment approach now taken for this unit in the Level 3 International Foundation Diploma for Higher Education Studies.

Time allowed: 2 hours

Instructions:

- Answer **ALL** questions.
- Clearly cross out surplus answers.
- Please refer to the formula sheet at the end of this examination paper.
- Any reference material brought into the examination room must be handed to the invigilator before the start of the examination.

Information:

- The maximum mark for this paper is 100.
- This paper contains THREE (3) section: A, B and C.
- Graph paper will be provided by the centre.
- **You may use a scientific calculator during this examination.**
- Note: Scientific calculators permitted in the exam should not be able to carry out algebraic manipulation, differentiation or integration, language translation or communication with other devices of the internet. They should not have a QWERTY keyboard. There should not be retrievable information stored in the calculator, for example databanks, dictionaries, mathematical formulas or text.

Section A – 24 MCQs. Total 24 marks

Answer these in your answer booklet – do NOT write on this Question Paper.
Write ONE (1) correct answer from A, B, C, or D for each question in your answer booklet.
Each question is worth 1 mark.

Marks

Question 1

Which subatomic particles are found in the nucleus of an atom? **1**

A Electrons only
B Protons and electrons
C Protons and neutrons
D Neutrons and electrons

Question 2

As temperature increases, what happens to the shape of the Boltzmann distribution curve? **1**

A It shifts to the left and becomes taller
B It shifts to the right and becomes spread-out
C It stays the same but moves upward
D It becomes narrower and taller

Question 3

How many isotopes of hydrogen are commonly known? **1**

A 1
B 2
C 3
D 4

Marks

Question 4

Why does silicon (Si) have the highest melting point among the elements in Period 3? **1**

A It has metallic bonding
B It forms covalent network structures
C It has weak Van der Waals forces
D It has ionic bonding

Question 5

What causes the ionisation energy to decrease down a group? **1**

A Increased nuclear charge and atomic number
B Increased atomic radius and shielding
C Decreased electron shielding and attraction
D Decreased number of shells and energy levels

Question 6

Which of the following chlorides undergoes hydrolysis when reacting with water, leading to an acidic solution? **1**

A $NaCl$
B $MgCl_2$
C $AlCl_3$
D KCl

Question 7

What does the empirical formula of a compound represent? **1**

A The exact number of atoms of each element
B The simplest whole number ratio of atoms of each element
C The mass of each element in the compound
D The molecular weight of the compound

Marks

Question 8

Which of the following elements is expected to have the largest atomic radius? **1**

A Lithium
B Potassium
C Nitrogen
D Fluorine

Question 9

Why do atoms form bonds? **1**

A To increase their atomic number through bonding
B To become radioactive and unstable over time
C To reach a stable outer electron arrangement
D To remove all electrons from the atom completely

Question 10

Which Group 17 element has the highest electronegativity? **1**

A F
B Cl
C Br
D I

Question 11

What type of bond is formed between oppositely charged ions? **1**

A Covalent bond
B Metallic bond
C Hydrogen bond
D Ionic bond

Marks

Question 12

Which of the following halide ions reacts with concentrated sulfuric acid without undergoing a redox reaction? **1**

A Fluoride ion (F^-)
B Chloride ion (Cl^-)
C Bromide ion (Br^-)
D Iodide ion (I^-)

Question 13

In metallic bonding, what are the metal atoms transformed into after losing their valence electrons? **1**

A Non-metals
B Covalent molecules
C Negative ions
D Positive ions

Question 14

What is the International Union of Pure and Applied Chemistry (IUPAC) name of the compound CH_3-CH_2-OH? **1**

A Methanol
B Propanol
C Ethanol
D Butanol

Marks

Question 15

What type of bond is formed when TWO (2) atoms share electrons? **1**

A Covalent bond
B Ionic bond
C Metallic bond
D Hydrogen bond

Question 16

Which class of organic compounds typically undergoes electrophilic addition reactions? **1**

A Alkanes
B Alcohols
C Carboxylic acids
D Alkynes

Question 17

Which of the following molecules has a bond angle of approximately 180°? **1**

A NH_3
B CH_4
C PF_5
D CO_2

Question 18

Among the given options, which one does not represent a form of structural isomerism? **1**

A Chain isomerism
B Positional isomerism
C Geometrical isomerism
D Functional group isomerism

Marks

Question 19

In a dot and cross diagram, what do the dots and crosses represent? **1**

A Neutrons and protons
B Shared and unshared bonds
C Electrons from different atoms
D Atoms of different sizes

Question 20

Which of the following statements is true about the S_N1 mechanism? **1**

A It is favoured by primary halogenoalkanes
B It involves a carbocation intermediate
C It is a one-step mechanism
D It requires a strong nucleophile

Question 21

Which of the following conditions is most likely to cause a gas to deviate from ideal behaviour? **1**

A Low temperature and high pressure
B High temperature and low pressure
C Low temperature and low pressure
D High temperature and high pressure

Question 22

Hydroxynitriles are formed by the reaction of: **1**

A Aldehydes and ketones with HCN
B Aldehydes and ketones with NaCN in NaOH
C Alcohols and HCN
D Carboxylic acids and HCN

Marks

Question 23

In a reaction pathway diagram, what does the peak represent? **1**

A The enthalpy of the reactants
B The enthalpy of the products
C The transition state
D The activation energy

Question 24

When an alkyl halide is treated with sodium hydroxide in an aqueous solution, the main organic product is: **1**

A Alcohol
B Alkane
C Alkene
D Aldehyde

Total 24 Marks

SECTION B – 16 questions. Total 45 marks
Answer ALL questions

Marks

Question 25

Define *atomic radius* and explain why atomic radii decrease across a period in the periodic table. **3**

Question 26

Explain how the oxides of Period 3 elements behave as acids or bases, using specific examples. Include the behaviour of aluminium oxide in your discussion. **3**

Question 27

Discuss THREE (3) factors that affect ionisation energy. **3**

Question 28

Describe why Group 2 elements become more reactive as you move down the group, referring to trends in ionisation energy and atomic structure. **3**

Question 29

A compound has an empirical formula of CH_2 and a relative molecular mass of FIFTY-SIX (56). **3**

Determine its molecular formula.

Question 30

Explain why hydrogen iodide (HI) is less thermally stable than hydrogen fluoride (HF), using ideas about atomic structure and bonding. **3**

Marks

Question 31

State and explain THREE (3) factors that affect electronegativity. **3**

Question 32

Explain, including THREE (3) reasons, why catalytic cracking is preferred over thermal cracking in the petrochemical industry, despite both processes achieving similar end results. **3**

Question 33

Describe a coordinate (dative) covalent bond? Give an example of a molecule that contains this type of bond. **2**

Question 34

Explain, using the mechanism of electrophilic addition, why bromine water rapidly decolourises when added to an **alkene** but not when added to an **alkane**. **3**

Question 35

Describe the main purpose of a dot and cross diagram? Give ONE (1) advantage and ONE (1) disadvantage of using these diagrams. **3**

Question 36

How can chloroethane (CH_3CH_2Cl) be converted into ethylamine ($CH_3CH_2NH_2$)? Name the type of reaction involved, state the reagents and conditions required, and write a balanced chemical equation for the process. **3**

Question 37

Explain the differing electrical conductivity in ionic, covalent and metallic substances. **3**

Marks

Question 38

Explain the process of addition polymerisation using ethene as an example. Describe how the polymer can be represented using a repeat unit, and why disposal of such polymers poses environmental concerns. **3**

Question 39

2-Methylpropan-1-ol can also be converted to produce diesel and jet fuel. The first step in the process is the production of 2-methylpropene. **2**

$C_4H_{10}O_{(l)}$ à $C_4H_{8(g)}$ + $H_2O_{(g)}$
2-methylpropan-1-ol 2-methylpropene

Using the data below, calculate the enthalpy change for the production of 2-methylpropene from 2-methylpropan-1-ol.

$4C_{(s)} + 5H_{2(g)} + ½O_{2(g)}$ à $C_4H_{10}O_{(l)}$ $\Delta H = -335$ kJ mol-1

$4C_{(s)} + 4H_{2(g)}$ à $C_4H_{8(g)}$ $\Delta H = -17$ kJ mol-1

$H_{2(g)} + ½O_{2(g)}$ à $H_2O_{(g)}$ $\Delta H = -242$ kJ mol-1

Question 40

Explain the disproportionation in the following reaction: **2**

$3Cl_2(aq) + 6NaOH(aq)$ à $5NaCl(aq) + NaClO_3(aq) + 3H_2O(l)$

Total 45 Marks

SECTION C – 7 questions. Total 31 marks
Answer ALL questions

Marks

Question 41

Discuss why sodium and phosphorus show different types of reactions with chlorine and water and explain how the oxidation states in their chlorides and oxides relate to their positions in the Periodic Table. **4**

Question 42

The table below shows successive ionisation energies of an element in Period 3. **4**

Explain in FOUR (4) points, how you would use this data to determine the group number of the element.

Ionisation Number	Ionisation Energy (kJ/mol)
1st	578
2nd	1817
3rd	2745
4th	11,578
5th	14,830

Question 43

Explain the trend in bond strength and volatility of halogens as you move down Group 17. **4**

Question 44

What volume of oxygen gas (in m^3) is produced when 32 g of potassium chlorate ($KClO_3$) decomposes at 300 K and a pressure of 101 kPa? (R = 8.31 J/mol·K). **5**

Where the balanced equation for the decomposition reaction is:
$2KClO_3(s)$ à $2KCl(s) + 3O_2(g)$

Marks

Question 45

Differentiate between homolytic and heterolytic fission by explaining:

a) the manner in which the bond breaks **1**

b) how electrons are redistributed and how this is depicted in reaction mechanisms. **1**

c) the types of species produced **1**

d) the influence of electronegativity. **1**

Total 4 Marks

Question 46

Explain why tertiary carbocations are more stable than secondary and primary carbocations. **4**

Question 47

Explain how *Le Chatelier's Principle* is applied to the Haber and Contact processes, to maximise product yield and discuss the role of catalysts in these processes. **6**

Total 31 Marks

End of paper

Periodic Table with the mass number and atomic number of each element.

1												13	14	15	16	17	18
1 **H** 1.008	2																2 **He** 4.0026
3 **Li** 6.94	4 **Be** 9.0122											5 **B** 10.81	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305	3	4	5	6	7	8	9	10	11	12	13 **Al** 26.982	14 **Si** 28.085	15 **P** 30.974	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.867	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.845	27 **Co** 58.933	28 **Ni** 58.693	29 **Cu** 63.546	30 **Zn** 65.38	31 **Ga** 69.723	32 **Ge** 72.630	33 **As** 74.922	34 **Se** 78.97	35 **Br** 79.904	36 **Kr** 83.798
37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.95	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57-71 *	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89-103 #	104 **Rf** (265)	105 **Db** (268)	106 **Sg** (271)	107 **Bh** (270)	108 **Hs** (277)	109 **Mt** (276)	110 **Ds** (281)	111 **Rg** (280)	112 **Cn** (285)	113 **Nh** (286)	114 **Fl** (289)	115 **MC** (289)	116 **Lv** (293)	117 **Ts** (294)	118 **Og** (294)

* Lanthanide Series	57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** [145]	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
# Actinide Series	89 **Ac** (227)	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

Nuclear Magnetic Spectroscopy data table

Approximate proton chemical shift values (δ) relative to TMS peak (0 on the scale)

Type of proton	Chemical Shift (ppm)
R----**CH_3**	0.9-1.1
R----**CH_2**----R	1.31.5
H_3C---C(=O) R**CH_2**-C(=O) R_2**HC**--C(=O) Aldehyde, Ketone, CAcid and Ester fragment	2.0-.2.7
H_2**C=C**	4.8-5.0
R----CH_2---**X**	3.2-4.3
R----**OH**	4.0-4.5
R------**COOH**	11.0-11.3
R----**CHO**	9.8-10.2
Ar----CH_3	2.3-3.0
Ar----OH	7.0-7.3
Ar----H	7.4-7.6

R = alkyl group
Ar = aryl (aromatic) group
X = halogen

Infrared Spectroscopy data table

Type of bond	Type of compound	Wave number range (cm^{-1})
Hydrogen bonded O − H stretch, strong and broad. Free (non-hydrogen bonded) O − H stretch, medium and sharp	Alcohol	3200 to 3550 3584 to 3700
C − H stretch C − H bend	Alkane	2853 to 2962 1340 to 1485
C − H stretch in C = C – H C = C stretch	Alkene	3010 to 3095 1620 to 1680
C=O stretch	Aldehyde, Ketones, Carboxylic acids and Esters	1680 to 1750
hydrogen bonded O − H stretch in −COOH	Carboxylic acids	2500 to 3500
C-Br C-Cl	Halogenalkanes	500 to 600 650-800
C − H stretch	benzene ring	3000 to 3100

Formulae

$\Delta H = cm\Delta T$ $(4{\cdot}18\ kJ\ kg^{-1}\ ºC^{-1})$

$$\% \text{ yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100$$

$$\% \text{ atom economy} = \frac{\text{Mass of desired product(s)}}{\text{Total mass of reactants}} \times 100$$

$n = cV$

$$\frac{C_1 x V_1}{n_1} = \frac{C_2 x V_2}{n_2}$$

$n = mGFM$

$$\text{rate} = \frac{\Delta \text{quantity}}{\Delta \text{ time}}$$

$pH + pOH = 14$

$pH = -\log_{10} [H^+]$

$K_w = [H^+] \times [OH^-]$

$pK_a = -\log_{10} K_a$

$pH = 1/2\ pK_a - 1/2 \log_{10} [\text{Concentration}]$

Physical constants

Avogadro's Constant $6.02 \times 10^{23}\ mol^{-1}$
Charge on electron $1.60 \times 10^{-19}\ C$