Example Year 1 AS Chemistry

Exam Questions and Mark Scheme

Name:

Class:

Date:

Time: **60 minutes**

Marks: **56 marks**

Comments:

1. (a) Nickel is a metal with a high melting point.

(i) State the block in the Periodic Table that contains nickel.

____

(1)

(ii) Explain, in terms of its structure and bonding, why nickel has a high melting point.

____

____

____

____

____

(2)

(iii) Draw a labelled diagram to show the arrangement of particles in a crystal of nickel. In your answer, include at least six particles of each type.

(2)

(iv) Explain why nickel is ductile (can be stretched into wires).

____

____

____

(1)

(b) Nickel forms the compound nickel(II) chloride ($NiCl_2$).

(i) Give the full electron configuration of the Ni^{2+} ion.

____

(1)

(ii) Balance the following equation to show how anhydrous nickel(II) chloride can be obtained from the hydrated salt using $SOCl_2$
Identify **one** substance that could react with both gaseous products.

......$NiCl_2.6H_2O(s)$ + ... $SOCl_2(g)$ $\longrightarrow$ ......$NiCl_2(s)$ + ...$SO_2(g)$ + ...$HCl(g)$

Substance ____

(2)

(Total 9 marks)

2. What is the best oxidising agent?

A F_2 ⬭

B F^- ⬭

C I_2 ⬭

D I^- ⬭

(Total 1 mark)

3. Which statement is correct about reactions involving halide ions?

A Sodium chloride forms chlorine when added to concentrated sulfuric acid. ⬭

B Sodium chloride forms chlorine when added to bromine. ⬭

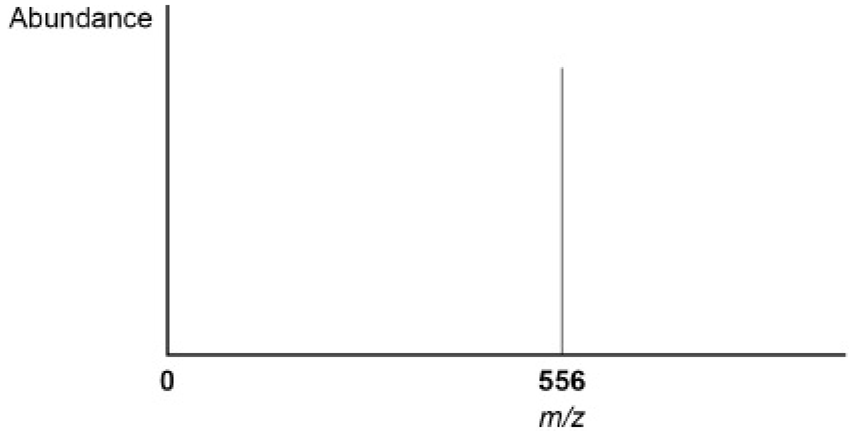
C Sodium bromide forms bromine when added to concentrated sulfuric acid. ⬭

D Sodium bromide forms bromine when added to iodine. ⬭

(Total 1 mark)

4. Time of flight (TOF) mass spectrometry can be used to analyse large molecules such as the pentapeptide, leucine encephalin (**P**).

P is ionised by electrospray ionisation and its mass spectrum is shown in the diagram.



(a) Describe the process of electrospray ionisation.

Give an equation to represent the ionisation of **P** in this process.

Description ____

____

____

____

____

____

____

____

____

Equation

____

(4)

(b) What is the relative molecular mass of **P**?
Tick (✓) **one** one box.

555 ☐ 556 ☐ 557 ☐

(1)

(c) A molecule **Q** is ionised by electron impact in a TOF mass spectrometer.
The $\mathbf{Q}^+$ ion has a kinetic energy of 2.09×10^{-15} J
This ion takes 1.23×10^{-5}s to reach the detector.
The length of the flight tube is 1.50 m

Calculate the relative molecular mass of **Q**.

$KE = \frac{1}{2}mv^2$ where m = mass (kg) and v = speed (m s $^{-1}$)
The Avogadro constant, $L = 6.022 \times 10^{23}$ mol^{-1}

Relative molecular mass ______________________________

(5)
(Total 10 marks)

5. This question is about fossil fuels.

(a) The petrol fraction from crude oil contains octane (C_8H_{18}).

Give an equation for the complete combustion of octane.

____

(1)

(b) The combustion of petrol in car engines produces the pollutant nitrogen monoxide.

Give an equation for a reaction that removes nitrogen monoxide in a catalytic converter.

____

(1)

(c) Sulfur dioxide is produced in the combustion of fossil fuels. The total emissions of sulfur dioxide in the UK have fallen dramatically since 1970.

Sulfur dioxide is now removed from the flue gases in power stations by reaction with calcium oxide.

$$CaO + SO_2 \rightarrow CaSO_3$$

In 1970, the total UK emissions of sulfur dioxide were 6.49 million tonnes (1 tonne = 1000 kg).

Calculate the mass, in kilograms, of calcium oxide needed to react with this mass of sulfur dioxide.

Give your answer in standard form.

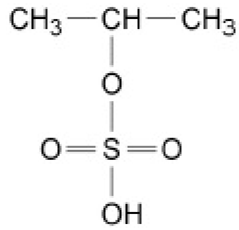
Mass of calcium oxide __________________________ kg

(2)

(Total 4 marks)

6. Propene reacts with concentrated sulfuric acid to form two isomers, E and F.

The structure of **E** is shown.



(a) Name and outline the mechanism for the formation of **E** in this reaction.

Name of mechanism ____

Mechanism

(5)

(b) Draw the structure of **F**.

(1)

(c) Explain why more of isomer **E** than isomer **F** is formed in this reaction.

(2)
(Total 8 marks)

7. Magnesium exists as three isotopes: ^{24}Mg, ^{25}Mg and ^{26}Mg

(a) In terms of sub-atomic particles, state the difference between the three isotopes of magnesium.

(1)

(b) State how, if at all, the chemical properties of these isotopes differ.

Give a reason for your answer.

Chemical properties ____

____

Reason ____

____

____

(2)

(c) ^{25}Mg atoms make up 10.0% by mass in a sample of magnesium.

Magnesium has A_r = 24.3

Use this information to deduce the percentages of the other two magnesium isotopes present in the sample.

^{24}Mg percentage = ________ % ^{26}Mg percentage = ________ %

(4)

(d) In a TOF mass spectrometer, ions are accelerated to the same kinetic energy (KE).

$KE = \frac{1}{2}mv^2$ where m = mass (kg) and v = velocity (m s^{-1})

$v = \frac{d}{t}$ where d = distance (m) and t = time (s)

In a TOF mass spectrometer, each $^{25}Mg^+$ ion is accelerated to a kinetic energy of 4.52×10^{-16} J and the time of flight is 1.44×10^{-5} s.
Calculate the distance travelled, in metres, in the TOF drift region.
(The Avogadro constant L = 6.022×10^{23} mol^{-1})

Distance = ___________________ m

(4)

(Total 11 marks)

8. A sample of hydrated nickel sulfate ($NiSO_4.xH_2O$) with a mass of 2.287 g was heated to remove all water of crystallisation. The solid remaining had a mass of 1.344 g.

(a) Calculate the value of the integer x.
Show your working.

____

____

____

____

____

____

____

____

____

____

(4)

(b) Suggest how a student doing this experiment could check that all the water had been removed.

____

____

____

____

(2)

(Total 6 marks)

9. This question is about the reactions of magnesium and its compounds.

(a) Magnesium is used in one of the stages in the extraction of titanium.

Give an equation for the reaction between titanium(IV) chloride and magnesium.
State the role of magnesium in this reaction.

Equation

____

Role of magnesium ____

(2)

(b) A mixture of magnesium oxide and magnesium hydroxide has a mass of 3200 mg

This mixture is reacted with carbon dioxide to form magnesium carbonate and water. The mass of water produced is 210 mg

$$Mg(OH)_2 + CO_2 \rightarrow MgCO_3 + H_2O$$

$$MgO + CO_2 \rightarrow MgCO_3$$

Calculate the percentage by mass of magnesium oxide in this mixture.

% of magnesium oxide ___________________________

(4)

(Total 6 marks)

1. (a) (i) d (block) **OR** D (block)

Ignore transition metals / series.

Do not allow any numbers in the answer.

1

(ii) Contains positive (metal) ions or protons or nuclei and delocalised / mobile / free / sea of electrons

Ignore atoms.

1

Strong attraction between them or strong metallic bonds

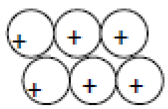
Allow 'needs a lot of energy to break / overcome' instead of 'strong'.

If strong attraction between incorrect particles, then CE = 0 / 2.

If molecules / intermolecular forces / covalent bonding / ionic bonding mentioned then CE=0.

1

(iii)



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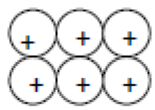


M1 is for regular arrangement of atoms / ions (min 6 metal particles).

M2 for + sign in each metal atom / ion.

Allow 2^+ sign.

2

(iv) Layers / planes / sheets of atoms or ions can slide over one another

QoL.

1

(b) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ (4s^0)$

Only.

1

(ii) $NiCl_2.6H_2O + \mathbf{6}\ SOCl_2 \longrightarrow NiCl_2 + \mathbf{6}\ SO_2 + \mathbf{12}\ HCl$

Allow multiples.

1

$NaOH$ / NH_3 / $CaCO_3$ / CaO

Allow any name or formula of alkali or base.

Allow water.

1

[9]

2. **A**

[1]

3. **C**

[1]

4. (a) **M1**: P dissolved or put in/added to a solvent

__M1__: Allow named solvent eg water or methanol

1

M2: (injected through) a needle or nozzle or capillary <u>and</u> at high voltage/4000 volts or high potential

__M2__: Allow needle is positively charged

1

M3: Gains a proton / H^+

__M3__: Not atoms gain a proton

__M3__: Could be scored from equation

1

M4: $P + H^+ \rightarrow PH^+$

Correct equation gains __M3__ and __M4__

Ignore state symbols

1

(b) 555

1

(c) **M1** $V = d/t$ or $= 1.22 \times 10^5$ ms^{-1}

Recall this equation

1

M2 $m = \frac{2KE}{v^2}$ or $\frac{2 \times 2.09 \times 10^{-15}}{(1.22 \times 10^5)^2}$

or

M2 $m = \frac{2KE \times t^2}{d^2}$ or $\frac{2 \times 2.09 \times 10^{-15} \times (1.23 \times 10^{-5})^2}{1.50^2}$

Rearrangement to give m

1

M3 $m = \underline{2.8(1) \times 10^{-25}}$ (kg)

***M3**: Calculation of m.*

1

M4 $= 2.81 \times 10^{-25} \underline{\times L} = 0.169$

***M4**: Allow **M3** × L*

1

M5 $0.169 \underline{\times 1000} = 169.(2)$

***M5**: Allow **M4** × 1000*

169 only scores 5 marks

Allow answers to 2 significant figures or more ignore units

1

[10]

5. (a) $C_8H_{18} + 12.5\ O_2 \rightarrow 8\ CO_2 + 9\ H_2O$

Allow multiples

Ignore state symbols

1

(b) $2\ NO + 2\ CO \rightarrow N_2 + 2\ CO_2$ ***or***

$25\ NO + C_8H_{18} \rightarrow 12.5\ N_2 + 9\ H_2O + 8\ CO_2$

Allow multiples

Ignore state symbols

Allow $2NO \rightarrow N_2 + O_2$ *(or multiples)*

1

(c)

M1 moles $SO_2 = \frac{6\ 490\ 000\ x\ 10^6}{64.1}$ ($= \frac{6.49\ x\ 10^{12}}{64.1}$ = 1.012 x 10^{11})

1

M2 mass CaO = $\left(\frac{1.012\ x\ 10^{11}\ x\ 56.1}{1000}\right)$ = 5.68 x 10^9 (kg)

1

M2 *must be in standard form*

Correct answer in standard form scores 2 marks (allow 5.6 – 5.7 × 10^9). Answer to at least 2sf.

Correct answer in non-standard form scores 1 mark

Answers that are 5.6 – 5.7 × 10^n score 1 mark

For other answers, allow ECF from ***M1*** *to* ***M2*** *(but answer must be in standard form for* ***M2*** *to score)*

Alternative

M1 mass CaO = $\frac{6\ 490\ 000\ x\ 10^6}{64.1}\ x\ 56.1$

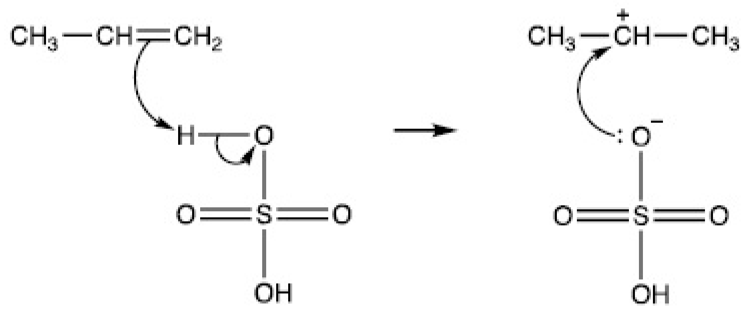
= 5.68 million tonnes

M2 *5.68 × 10^9 (kg)*

(7.4.. × 10^9 would score 1 mark due to use of $\frac{64.1}{56.1}$)

[4]

6. (a) **M1** electrophilic addition



*All arrows are double-headed. Penalise one mark from the total for **M2-5** if half headed arrows are used.*

Do not penalise the "correct" use of "sticks"

Penalise only once in any part of the mechanism for a line and two dots to show a bond

1

M2 must show an arrow from the double bond towards the H atom of the H_2SO_4 molecule

*For **M2/3**, the full structure of H_2SO_4 does not need to be shown, but the key features for the mechanism should be shown and the formula must be correct. Penalise only once in **M2/3** an incorrect but genuine attempt at the structure of sulfuric acid*

***M2** ignore partial negative charges on the double bond*

1

M3 must show the breaking of the H-O bond in H_2SO_4

***M3** penalise incorrect partial charges on the H–O bond and penalise formal charges*

1

M4 is for the structure of the correct carbocation

*Penalise **M4** if there is a bond drawn to the positive charge*

1

M5 must show an arrow from the lone pair of electrons on the negatively charged oxygen of HSO_4^- towards the positively charged atom of their carbocation drawn

***Max 3 of 4 marks** (**M2-5**) for wrong organic reactant or wrong carbocation (ignore structure of product)*

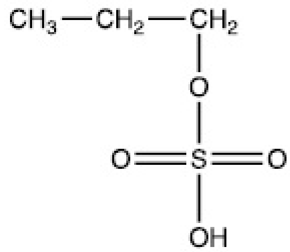
1

*If attack is shown from C=C to H^+ rather than H_2SO_4, then allow **M2** but not **M3***

*For **M5**, credit attack on a partially positively charged carbocation structure, but penalise **M4** for the structure of the carbocation.*

*For **M5**, the full structure of HSO_4^- is not essential, but attack must come from a lone pair on an individual oxygen on HSO_4^-, but the – sign could* *by anywhere on the ion (e.g.: OSO_3H^-)*

(b)



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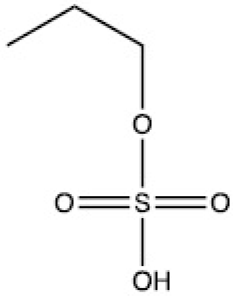

Any correct structural formula, including OSO_3H bonded through O to correct C

1

(c) **M1** idea that **E** is formed from/via more stable carbocation

__M1-2__ Allow carbonium ion in place of carbocation

1

M2 idea that 2^y carbocation is more stable than 1^y carbocation

__M2__ Allow descriptions in terms of number of alkyl groups attached to positive C atom

1

Ignore reference to inductive effect

Penalise __M1__ if answer suggests that the products are carbocations (but could score __M2__)

In order to access __M1__ and/or __M2__ there must be some reference to carbocations (carbonium ions) by name or structure or description

[8]

7. (a) ^{24}Mg has 12n; ^{25}Mg has 13n; ^{26}Mg has 14n

OR They have different numbers of neutrons

1

(b) No difference in chemical properties

1

Because all have the same electronic structure (configuration)

OR they have the same number of outer electrons

1

(c) If fraction with mass 24 = x

Fraction with mass 26 = 0.900 − x

Fraction with mass 25 = 0.100

1

$A_r = 24x + (25 \times 0.100) + 26(0.900 - x)$

1

$24.3 = 24x + 2.50 + 23.4 - 26x$

$2x = 1.60$

x = 0.800 i.e. percentage ^{24}Mg = 80.0(%) (80.0% 3sf)

1

^{26}Mg = 0.900 − 0.800 = 0.100 ie percentage ^{26}Mg = 10.0(%)

1

(d) $m = {}^{25/1000}/_{6.022 \times 10^{23}}$

1

$v^2 = 2ke/m$ or $v^2 = \dfrac{2 \times (4.52 \times 10^{-16}) \times (6.022 \times 10^{23})}{25/1000}$

1

$V = \sqrt{2.18 \times 10^{10}} = 1.48 \times 10^{5}$ (ms^{-1})

1

$D = vt = 1.48 \times 10^{5} \times 1.44 \times 10^{-5}$

D = 2.13 (m)

1

[11]

8. (a) 0.943 g water (M1)

If Mr of $NiSO_4$ wrong, can allow M1 and M3 from method 1 i.e. max 2

$NiSO_4$	H_2O
$\frac{1.344}{154.8}$ (M2)	$\frac{0.943}{18}$ (M3)
(8.68×10^{-3}	0.052)
1	6 or x = <u>6</u> (M4)

Allow Mr = 155

Allow other methods e.g.

M_r ($NiSO_4$) = 58.7 + 32.1 + 64.0 = 154.8

n($NiSO_4$) = $\frac{1.344}{154.8}$ = 0.008682 mol (M1)

M_r ($NiSO_4.xH_2O$) = $\frac{2.287}{0.008682}$ = (263.4) (M2)

so $18x = 263.4 - 154.8 = (108.6)$ (M3)

so $x = \frac{108.6}{18} = \underline{6}$ (M4)

If using alternative method and Mr of $NiSO_4$ wrong, allow ecf to score M2 and M3 only i.e. max 2

4

(b) re-heat

Heat to constant mass = 2 marks

1

check that mass is unchanged

M2 dependent on M1

Allow as alternative:

M1: record an IR spectrum

M2: peak between 3230 and 3550 (cm^{-1})

1

[6]

9. (a) Equation: $2\ Mg + TiCl_4 \rightarrow Ti + 2\ MgCl_2$

Allow multiples / ignore ss

1

Role: Reducing agent

Allow electron donor (not electron pair donor)

1

(b) **M1**: moles of water in 210 mg = mass / mr = 0.210 / 18
= 0.0117 mol ONLY

Equal to moles of magnesium hydroxide produced in stage one

M2: mass of $Mg(OH)_2$ = 0.0117 x 58.3 = 0.680 g

M3: mass of MgO = 3.2 – 0.68

= 2.52 g

M1 *= moles of water*
M2 *= mass of* $Mg(OH)_2$ *=* ***M1*** *x 58.3*
M3 *= subtraction = 3.2 –* ***M2***
M4 *= answer to* ***M3*** *x 100/3.2*

Accept correct alternative methods such as
M1 *= moles of water*
M2 *= mass of* $Mg(OH)_2$ *=* ***M1*** *x 58.3*
M3 *=* ***M2*** *x 100/3.2*
M4 *= 100 –* ***M3***

M4: % of MgO = 2.52/3.2 x 100 = 78.7%

M4*: Allow 78.7 – 78.8 or 79 %*

4

[6]