



*Rewarding Learning*

**ADVANCED SUBSIDIARY (AS)  
General Certificate of Education  
2023**

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## **Life and Health Sciences**

**Assessment Unit AS 3**  
*assessing*

Aspects of Physical Chemistry in  
Industrial Processes

**[SZ031]**

**MONDAY 5 JUNE, AFTERNOON**

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**MARK  
SCHEME**

## General Marking Instructions

### Introduction

Mark schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes teachers and students will be able to see what examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather with rewarding students for what they do know.

### The Purpose of Mark Schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of students in schools and colleges.

The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes, therefore, are regarded as part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. What is published represents this final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example, where there is no absolute correct response – all teachers will be familiar with making such judgements.

- 1 (a) (i) Cost per unit of product/ongoing costs to run the process [1]
- (ii) **Capital** – Purchase of land/purchase of machinery/construction of plant/design fees  
**Direct** – Cost of raw materials/cost of fuel/cost of packaging/electricity costs to maintain process/transport  
**Indirect** – Sales and advertising/machinery maintenance/rent/insurance/heating/research and development/labour (or other appropriate) [3]
- (iii) Reactants are added as the product is removed [1]
- (b) (i)  $N_2 + 3H_2 \rightleftharpoons 2NH_3$   
Correct formulae [1]  
Correct balancing [1] (dependent on correct formulae)  
Correct arrow [1] [3]
- (ii) Pressure 200–300 [1] atm [1]  
Catalyst Iron [1] [3]
- (c) (i) (The catalyst is) in a different (physical) state to the reactants [1]
- (ii) Process name: Chemisorption [1]  
Any **three** from:  
• Reactants adsorb to the catalyst surface  
• Bonds weaken/break  
• Reactants form products/react  
• Product(s) desorb from (catalyst) surface [4]
- (d) (i) When the rates of the forward and backwards reactions are equal [1]  
Concentrations of reactants and products remain constant [1] [2]
- (ii) Position of equilibrium moves to the left [1]  
Moves in endothermic direction (to remove heat)/forward reaction is exothermic [1] [2]

AVAILABLE  
MARKS

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2 (a) (i) **Indicative content:**

- Use polystyrene cup/calorimeter
- Use a measuring cylinder/pipette
- Use a thermometer
- Idea of measuring a certain volume of HCl
- Record temperature (initial)
- Idea of measuring a certain volume of NaOH
- Add HCl to NaOH/add together
- Stir the solution (of HCl and NaOH)
- Put lid on
- Record highest temperature reached

Level of response	Marking Criteria	Marks
<b>Excellent</b>	Candidate clearly articulates the process for finding the enthalpy of neutralisation. There is excellent use of spelling, punctuation and grammar. Form and style are of an excellent standard using <b>7 or more</b> indicative points.	[5]–[6]
<b>Good</b>	Candidate provides a good description of the process for finding the enthalpy of neutralisation. There is good use of spelling, punctuation and grammar. Form and style are of a good standard using <b>4–6</b> indicative points.	[3]–[4]
<b>Basic</b>	Candidate provides a limited description of the process for finding the enthalpy of neutralisation. There is limited use of spelling, punctuation and grammar. Form and style are of basic standard. <b>1–3</b> indicative points used.	[1]–[2]
	This response is not worthy of credit	[0]

[6]

(ii) Use the equation  $Q = mc\Delta T$  [1] where  $m$  is the mass of water/solution [1],  $c$  is the specific heat capacity (of water) [1] and  $\Delta T$  is the change in temperature [1] [4]

(iii) Any **two** from:

- Heat loss to the surroundings/air (qualified)
- Incomplete neutralisation/reaction
- Human error in measuring (must be qualified) [2]

(b) (i) The energy/enthalpy required to break one mole of a given bond [1] averaged over many compounds [1] [2]

(ii) Bonds broken =  $(3 \times 413) + (1 \times 358) + (1 \times 467) + (1\frac{1}{2} \times 495) = 2806.5$  [1]  
 Bonds made =  $(2 \times 799) + (4 \times 467) = 3466$  [1]  
 Enthalpy change = bonds broken – bonds made =  $2806.5 - 3466$  [1] ecf  
 Enthalpy change =  $-659.5 \text{ kJ mol}^{-1}$  [1] ecf [4]

AVAILABLE  
MARKS

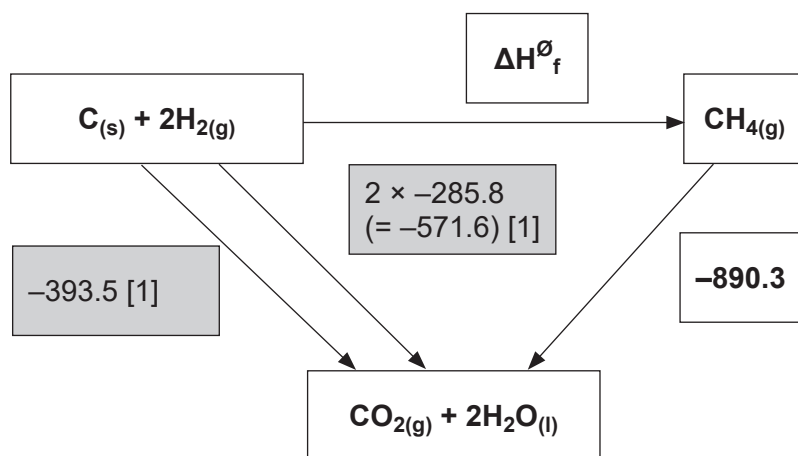
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- 3 (a) (i) RFM NaOH = 23 + 16 + 1 = 40 [1]  
= 40 × 0.1 ecf  
= 4g [1] [2]
- (ii) A solution for which the concentration is (accurately) known [1]
- (b) Indicator: Phenolphthalein methyl orange (threshold) [1]  
Colour change: colourless to pink/red to yellow [2]  
Award for colour change [1] if colours correct, but wrong way round [3]
- (c) (i) Accurate: 49.0 [1]  
Mean: (22.5 + 22.4)/2 = 22.5 [1] [2]
- (ii) NaOH + HNO<sub>3</sub> → NaNO<sub>3</sub> + H<sub>2</sub>O [1]
- (iii) moles NaOH = 22.5 × 0.1/1000 = 0.00225 moles (allow ecf) [1]
- (iv) Ratio is 1:1 therefore 0.00225 moles of HNO<sub>3</sub> [1]  
0.00225 × 1000/25.0 = 0.09 mol dm<sup>-3</sup> [1] (allow ecf) [2]

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- 4 (i) The change in heat energy (threshold) [1] in a reaction (at constant pressure) measured at standard conditions [1] [2]
- (ii) 298 [1] K [1]  
100 (kPa) [1] [3]

(iii)



[2]

- (iv) = -393.5 + (2 × -285.8) - (-890.3) [1] (allow ecf)  
= -74.8 kJ mol<sup>-1</sup> [1] [2]
- (v) Exothermic as the value of ΔH is negative ecf [1]

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			AVAILABLE MARKS
<b>5</b>	<b>(a)</b>	<b>(i)</b> A reaction which can go in both the forwards and backwards direction	[1]
	<b>(ii)</b>	$2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3$  Correct formulae [1] Correct balancing [1] (dependent on correct formulae)	[2]
	<b>(iii)</b>	Yield increases [1] as position of equilibrium shifts to the right-hand side as there are less molecules [1]	[2]
	<b>(iv)</b>	Energy profile diagram drawn with reactants higher than products [1] Axes labelled (energy and progress of reaction) or other suitable [2]	[3]
	<b>(b)</b>	<b>(i)</b> Curve added has a lower peak [1] and is shifted to the right [1]. Tail is higher [1]. Same general shape.	[3]
	<b>(ii)</b>	Vertical line drawn towards beginning of tail/ line/mark on x axis towards beginning of tail	[1]
	<b>(iii)</b>	Rate increases [1] Catalyst lowers $E_A$ [1] Larger area under curve past $E_A$ / More particles with enough energy to successfully collide per unit time/more successful collisions per unit time [1]	[3]
<b>Total</b>			<b>15</b>
<b>Total</b>			<b>75</b>