Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2025

Life and Health Sciences

Assessment Unit AS 3

assessing

Aspects of Physical Chemistry in Industrial Processes

[SZ031]

MONDAY 2 JUNE, AFTERNOON

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.

AVAILABLE MARKS

1 **(a)** **(i)** A continuous process is a non-stop process [1] where products are removed at the same time as new reactants are added. [1] [2]

(ii) Any **two** from:
- Close to good road/rail links (for transport of raw materials/distribution of product)
- Close to a town/population (to provide workers)
- May need to be close to a source of bulk raw materials (to reduce transport costs) [2]

(b) **(i)** Reversible (reaction) [1]

(ii) 400 − 450°C [1]
200atm [1]
Iron (Fe) [1] [3]

(iii) M_r of N_2= 28 [1]
2000 kg = 2000000 g [1]
$n = \frac{m}{M_r}$ **or** substituted correctly [1]
$= \frac{2\,000\,000}{28}$ [1] [3]

(iv) $M_r = 17$ [1]

(v) Ratio N_2:NH_3 is 1:2
71428.57 × 2 = 142857.14 moles of NH_3 [1]
$m = n \times M_r$
142857.14 × 17 [1] allow ecf from **(iv)**
$\frac{2428571.38}{1000}$ = 2428.57kg [1] [3]

(vi) 607.143kg allow ecf from **(v)** [1]

(vii) Side reactions/reaction not to completion/impure reactants [1] 17

AVAILABLE MARKS

2 (a) (i) A substance which increases the rate of a chemical reaction [1] without being used up [1] [2]

(ii) Heterogeneous [1]

(iii) Find gradient at time x [1]

(iv) Start at origin, steeper curve than original, plateau sooner [1]

(b) **Effect:** Faster [1] Threshold
Explanation:
- particles have increased kinetic energy/are moving faster/more particles have energy greater than or equal to E_a [1]
- (More frequent collisions and so) more successful collisions per unit time [1] [3] — 8

3 (a) (i) Any **eight** from:

Measure out and transfer the sodium hydroxide solution
- Rinse pipette with sodium hydroxide solution
- Fill pipette to bottom of the meniscus/to mark (using a pipette filler)
- Transfer ($25.0 cm^3$) of sodium hydroxide solution to conical flask
- Touch pipette on top of solution

Prepare and fill the burette
- Rinse burette with sulfuric acid solution/standard solution
- Fill burette with sulfuric acid (to mark bottom of meniscus)
- Ensure there are no air bubbles/jet filled

Carry out an accurate titration
- Add drops of indicator to flask
- (Titrate until) colour change
- Swirl mixture
- Add dropwise (near endpoint) [8]

(ii)

Phenolphthalein [1] Threshold		methyl orange [1] Threshold
pink [1]	**or**	yellow [1]
to colourless [1]		red [1]

Award [1] for colours if wrong way round [3]

AVAILABLE MARKS

(b) (i) Initial volume: 0.1 [1]
Final volume: 14.5 [1] [2]

(ii) 14.5 [1]
Justification:
Concordant results used / the titre volumes used are +/−0.1cm^3 [1] [2]

(c) (i) $\frac{15.0\,cm^3}{1000} = 0.015\,dm^3$ [1]
n = cv
= 0.1 × 0.015 = 0.0015 [1]
= 0.0015 (moles) [2]

(ii) Molar ratio NaOH : H_2SO_4 is 2:1 therefore
0.0015 × 2 = 0.003 moles NaOH [1] ecf
$c = \frac{n}{v}$
$= \frac{0.003}{0.025} = 0.12\,mol\,dm^{-3}$ [1] [2] 19

AVAILABLE MARKS

4 (a) (i) $\sum\Delta H_c$ reactants: [(3 × −394) [1] + (4 × −286)] [1] = −2326 [1]
$\sum\Delta H_c$ products: [−2220] [1]
$\Delta H = \sum\Delta H_c$ reactants – $\sum\Delta H_c$ products
= [−1182−1144] + [2220] = −106 [1] [4]

(ii) reactants on left/products on right labelled [1]
Exothermic reaction profile diagram shape [1]
axes labelled correctly [1]
(x – reaction pathway, y – energy or suitable alternative) [3]

(b) (i) (The enthalpy change) when one mole of a substance [1]
is completely burned in oxygen under standard conditions [1] [2]

(ii) Indicative content:

- add measured volume/100cm^3 of (cold) water (using a measuring cylinder) – use a calorimeter
- use a calorimeter/beaker/conical flask
- weigh the spirit burner (and cap)
- record the initial temperature of the water
- place the spirit burner under the calorimeter light the wick
- stir
- (replace the cap to) extinguish the flame
- re-weigh the spirit burner (and cap)
- record highest temperature
- (using a fresh 100cm^3 of cold water) repeat the experiment

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

[6]

	AVAILABLE MARKS
(c) **(i)** $Q = mc\Delta t$ / Q=100 [1] × 4.2 × 11 mass OR ecf × 4.2 × 11 = 4620 [1] Unit = Joules/J [1] [3]	
(ii) Mass of propanol burned = 0.23g M_r propanol = 60 [1] $= \frac{0.23}{60}$ ecf [1] = 0.00383333 → 0.0038 (4dp) [1] [3]	
(iii) $\frac{(-)4620}{0.0038}$ = 1215789.47 J mol^{-1} [1] (ecf from **(ii)**) = 1215.789 kJ mol^{-1} [1] nearest whole number: −1216 (kJ mol^{-1}) [1] [3]	24
5 **(a)** Dynamic equilibrium is when the rate of the forward reaction and reverse reaction are equal [1] and concentrations/amounts of reactants and products remains constant [1] [2]	
(b) **(i)** 300 °C 400 atm [1]	
(ii) Temperature • The reverse reaction is the endothermic reaction • As temperature increases, the position of equilibrium shifts to the left to oppose the change/reverse reaction favoured (accept converse) [2]	
(iii) Pressure • Less moles on right hand side/5 moles vs 3 moles • As pressure increases, the position of equilibrium shifts to the right/forward reaction is favoured [2]	7
Total	**75**