

OCR A-LEVEL CHEMISTRY B (SALTERS) • H433

# CHEMISTRY



**EXAM QUESTION PACK**

**ELEMENTS FROM THE SEA (ES)**

**SCORE**

**/54**

**PERCENTAGE**

**%**

**STEMUP**

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- 1 Reversible reactions reach dynamic equilibrium.

What is correct about these equilibria?

- A They must be set up in a closed system.
- B The overall concentrations remain constant because molecules have stopped reacting.
- C The rates of the forward and reverse reactions are zero.
- D The position of equilibrium is always independent of temperature.

Your answer

[1]

- 2 Some students want to find the concentration of chloride ions in seawater. They look up a method in a textbook.

They dilute the seawater and then titrate with standard silver nitrate,  $\text{AgNO}_3$ , solution.

- (i) Describe what is observed when silver nitrate is added to the seawater.

----- [1]

- (ii) Give an ionic equation for the reaction, including state symbols.

[1]

- 3 Some students use a method based on an electrochemical cell to measure the concentration of silver ions in solution.

They set up a cell as shown in Fig. 2.1.

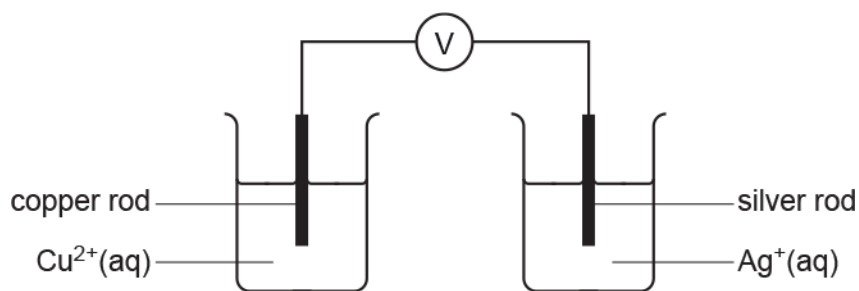


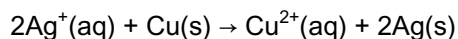
Fig. 2.1

Table 2.1 shows the electrode potential data for the cell in Fig. 2.1.

| Half-equation                                                                    | $E^\circ / \text{V}$ |
|----------------------------------------------------------------------------------|----------------------|
| $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Cu}(\text{s})$ | +0.34                |
| $\text{Ag}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{Ag}(\text{s})$     | +0.80                |

Table 2.1

Equation 2.1 shows the reaction that occurs when the standard cell delivers a current.



Equation 2.1

- (i) Identify the oxidising agent in equation 2.1.

----- [1]

- (ii) State and explain which way electrons flow in the wire when the standard cell is delivering a current.

-----  
----- [1]

- 4 'Fumaric acid' is used as an acidity regulator in food. 'Maleic acid' is a stereoisomer of fumaric acid. The structure of the two acids are shown in Fig. 4.1.

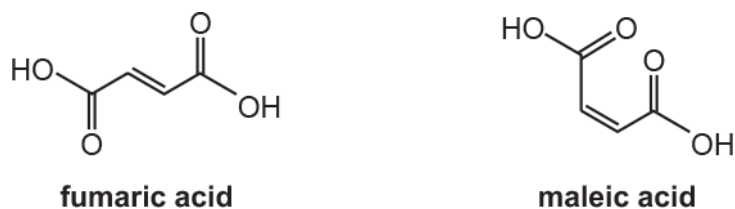
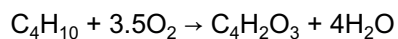
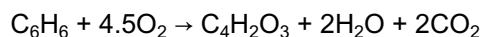


Fig. 4.1

Maleic anhydride,  $C_4H_2O_3$ , can be made industrially by oxidising butane or benzene.



Reaction 1



Reaction 2

- (i) Use calculated atom economies to suggest, with a reason, which reaction is used more.

-----  
----- [2]

- (ii) Suggest another reason why the reaction selected in (g)(i) is preferred.

-----  
----- [1]

- (iii) Calculate the maximum mass of maleic anhydride,  $C_4H_2O_3$ , (in kg) that could be made from  $15 \text{ m}^3$  of butane (measured at RTP).

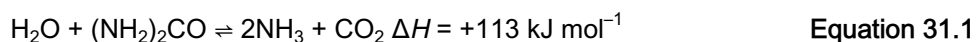
Give your answer to an **appropriate** number of significant figures.

mass of maleic anhydride = ..... kg [2]

5(a) There is a high air concentration in the air-fuel mix of diesel engines. This makes the formation of oxides of nitrogen more likely.

Urea,  $(\text{NH}_2)_2\text{CO}$ , is used in the exhaust system to remove oxides of nitrogen.

The urea reacts in the exhaust system as shown in **equation 31.1**.



(i) The forward reaction in **equation 31.1** is only feasible above a certain temperature.

Use the entropy values in the table to calculate this temperature.

| Substance                  | Entropy, $\text{S/J mol}^{-1} \text{ K}^{-1}$ |
|----------------------------|-----------------------------------------------|
| $\text{H}_2\text{O}$       | + 69.9                                        |
| $(\text{NH}_2)_2\text{CO}$ | + 173.9                                       |
| $\text{NH}_3$              | + 192.3                                       |
| $\text{CO}_2$              | + 213.6                                       |

temperature = ..... K [3]

(ii) **Equation 31.1** is repeated again below.



The ammonia produced in **equation 31.1** reacts with oxygen and NO in the presence of a catalyst. Water and nitrogen are formed.

Construct the equation for this reaction.

- (b) It has been stated that cars cause the most pollution on short journeys.

Evaluate this statement in terms of the rate and equilibrium position of the reaction shown in **equation 31.1**.

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[4]

- (c) The urea used in the exhaust system is manufactured from ammonia and carbon dioxide.  
The production of ammonia is given by **equation 31.2**.



In an experiment 5.0 moles of nitrogen and 12.0 moles of hydrogen are allowed to reach equilibrium in a 1.0 dm<sup>3</sup> container.

When analysing the equilibrium mixture, it was found that 6.0 moles of ammonia have been formed.

Calculate the concentrations of each gas at equilibrium and find the equilibrium constant for the equilibrium in **equation 31.2** under these conditions.

Include the units in your answer.

$K_c = \dots\dots\dots$  units  $\dots\dots\dots$  [4]

6(a) The Dead Sea has high concentrations of salts, especially chlorides and bromides.  
Chlorine and bromine factories have developed next to the Dead Sea.

Many of the industries using chlorine and bromine as raw materials are located nearby. This avoids transporting these substances over long distances.

Give **one** hazard of transporting chlorine or bromine.

-----  
----- [1]

(b) Chlorine is obtained by electrolysis. The chlorine is then used to obtain bromine from the bromide ions in the Dead Sea.

(i) Describe what is seen when chlorine is added to a solution of bromide ions.

----- [1]

(ii) Give an ionic equation for the reaction that takes place.

[1]

(iii) Explain, in terms of electrons, why the reaction takes place.

----- [1]  
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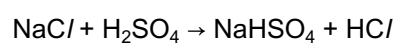
(iv) The density of Dead Sea water is  $1.24 \text{ kg dm}^{-3}$ .  
The concentration of chloride ions is  $208 \text{ g dm}^{-3}$ .

Calculate the volume of chlorine (in  $\text{dm}^3$  at RTP) that is obtained by electrolysis 1.00 tonne of the water.

Give your answer in **standard form**.

volume of chlorine = ..... dm<sup>3</sup> [4]

(c) Hydrogen chloride can be prepared by the action of concentrated sulfuric acid on sodium chloride.



(i) Explain why hydrogen chloride is a gas at room temperature.

-----

----- [1]

(ii) Write an equation to show why hydrogen chloride dissolves in water to form an acidic solution.

[1]

(d) If the concentrated sulfuric acid is added to sodium bromide, some of the hydrogen bromide produced reacts with sulfuric acid to form sulfur dioxide and bromine.

(i) Complete the oxidation states of Br and S in the table.

|                       | HBr   | H <sub>2</sub> SO <sub>4</sub> | Br <sub>2</sub> | SO <sub>2</sub> |
|-----------------------|-------|--------------------------------|-----------------|-----------------|
| Oxidation state of Br | ..... |                                | .....           |                 |
| Oxidation state of S  |       | .....                          |                 | .....           |

[2]

(ii) Construct an equation for the reaction of concentrated sulfuric acid with hydrogen bromide.

[1]

7(a) 'Monopotassium phosphate',  $\text{KH}_2\text{PO}_4$ , is added to fertilisers.  
 $\text{KH}_2\text{PO}_4$  acts as a buffer and supplies phosphorus.

The  $\text{H}_2\text{PO}_4^-$  ion has two OH groups.

Draw a 'dot-and-cross' diagram for this ion.

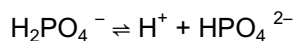
[2]

(b)  $\text{KH}_2\text{PO}_4$  when used in fertilisers is said to be equivalent to 52%  $\text{P}_2\text{O}_5$  and 34%  $\text{K}_2\text{O}$  by mass.

Show that the mole ratio of potassium to phosphorus in 52%  $\text{P}_2\text{O}_5$  and 34%  $\text{K}_2\text{O}$  is the same as in  $\text{KH}_2\text{PO}_4$ .

[2]

(c) In a solution of  $\text{KH}_2\text{PO}_4$ , the equilibrium in **equation 3.1** occurs:



$$K_a = 6.2 \times 10^{-8} \text{ mol dm}^{-3}$$

**Equation 3.1**

(i) Identify the base in this reaction and explain your choice.

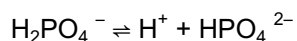
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----- [1]

(ii) Calculate the  $\text{p}K_a$  for the equilibrium in **equation 3.1**.

$\text{p}K_a = \dots\dots\dots$  [1]

**Equation 3.1** is repeated again.



$$K_a = 6.2 \times 10^{-8} \text{ mol dm}^{-3}$$

**Equation 3.1**

(iii) Calculate the pH of a  $1.0 \times 10^{-3} \text{ mol dm}^{-3}$  solution of  $\text{KH}_2\text{PO}_4$ .

$\text{pH} = \dots\dots\dots$  [2]

(d) The acidity of  $\text{KH}_2\text{PO}_4$  reduces the loss of ammonia from ammonium ions ( $\text{NH}_4^+$ ) in a fertiliser.

Explain how this happens when the fertiliser is in solution.

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----- [2]

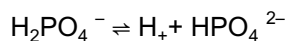
(e) A mixture of  $\text{HPO}_4^{2-}$  and  $\text{H}_2\text{PO}_4^-$  ions in solution makes a 'phosphate buffer'.

Calculate the mass of  $\text{KH}_2\text{PO}_4$  that must be added to  $1.0 \text{ dm}^3$  of a  $0.10 \text{ mol dm}^{-3}$  solution of  $\text{HPO}_4^{2-}$  to make a solution with a pH of 6.50.

The volume of the solution does not change when the solid is added.

mass of  $\text{KH}_2\text{PO}_4$  = ..... g [4]

Equation 3.1 is repeated again.



$$K_a = 6.2 \times 10^{-8} \text{ mol dm}^{-3}$$

Equation 3.1

(f)

- (i) A student says that a solution of  $\text{HPO}_4^{2-}$  alone will act as a buffer when acid is added.  
The student says that this is because the position of equilibrium in **equation 3.1** moves to the left to remove  $\text{H}^+$  ions.

Discuss the student's statements.

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----- [2]

- (ii) A student is doing calculations involving solutions of hydrochloric acid.

The student says that the concentration of hydrogen ions can be taken as the concentration of the acid.

Discuss this statement.

-----

----- [1]

- (iii) Calculate the **change** in pH when 1 drop ( $0.05 \text{ cm}^3$ ) of  $0.01 \text{ mol dm}^{-3} \text{ HCl}$  is added to  $1.0 \text{ dm}^3$  of water at pH 7.0.

pH change = ..... [2]

**END OF QUESTION PAPER**



### Mark Scheme

| Question |  |     | Answer/Indicative content                                                                                                                                                                                         | Marks                    | Guidance                                                                                                                                                                                                                                           |
|----------|--|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1        |  |     | A                                                                                                                                                                                                                 | 1 (AO2.2)                |                                                                                                                                                                                                                                                    |
|          |  |     | <b>Total</b>                                                                                                                                                                                                      | <b>1</b>                 |                                                                                                                                                                                                                                                    |
| 2        |  | i   | White precipitate ✓                                                                                                                                                                                               | 1 (AO1.2)                |                                                                                                                                                                                                                                                    |
|          |  | ii  | $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$ ✓                                                                                                                             | 1 (AO1.2)                |                                                                                                                                                                                                                                                    |
|          |  |     | <b>Total</b>                                                                                                                                                                                                      | <b>2</b>                 |                                                                                                                                                                                                                                                    |
| 3        |  | i   | silver <u>ions</u> / $\text{Ag}^+$ ✓                                                                                                                                                                              | 1 (AO1.2)                | <u>Examiner's Comments</u><br>Most candidates scored some marks in this part but did not score full marks as they gave incomplete answers. In part (i) the temperature was usually stated but not the concentration of the solutions.              |
|          |  | ii  | From Cu to Ag<br><b>AND</b> Cu electrode potential is more negative / less positive ✓                                                                                                                             | 1 (AO2.3)                | <b>ALLOW</b> Ag electrode is more positive / less negative<br><b>ALLOW</b> Cu is oxidised / loses electrons<br><b>ALLOW</b> $\text{Ag}^+$ ions are reduced / accept electrons                                                                      |
|          |  |     | <b>Total</b>                                                                                                                                                                                                      | <b>2</b>                 |                                                                                                                                                                                                                                                    |
| 4        |  | i   | Atom economies $(98/170) = 58\%$ <b>AND</b> $(98/222) = 44\%$ ✓<br><br>Identifies butane / reaction 1 should be used because it has the larger atom economy / produces less waste ✓                               | 2 (AO2.6)<br><br>(AO3.1) | <b>ALLOW</b> 0.58 <b>AND</b> 0.44<br><br><u>Examiner's Comments</u><br>Parts(i) and (ii) were well answered by most candidates, although (iii) saw marks being lost for use of an inappropriate number of significant figures in the final answer. |
|          |  | ii  | Benzene toxic / more expensive / butane more available from cracking / doesn't produce $\text{CO}_2$ (ORA for reaction 2)✓                                                                                        | 1 (AO3.1)                | <b>ALLOW</b> ecf from (i) eg butane more flammable                                                                                                                                                                                                 |
|          |  | iii | <b>FIRST CHECK THE ANSWER ON ANSWER LINE</b><br><b>If answer = 61 (kg) award 2 marks</b><br><br>amt butane = $15000/24 = 625 \text{ mol}$ ✓<br><br>mass maleic anh = $625 \times 98/1000 = 61(\text{kg})$ (2sf) ✓ | 2 (AO2.8 × 2)            | 61.3 or 61.2 score 1<br><br>Correct use of gas equation can score both marks                                                                                                                                                                       |

## Mark Scheme

| Question |  |  | Answer/Indicative content | Marks | Guidance |
|----------|--|--|---------------------------|-------|----------|
|          |  |  | Total                     | 5     |          |

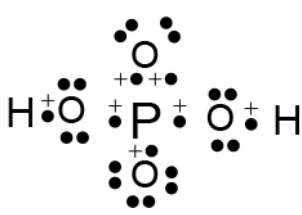
### Mark Scheme

| Question |   |    | Answer/Indicative content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Marks                                      | Guidance                                                                                                                                                                                                                                                                                                                                                              |
|----------|---|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5        | a | i  | <p><b>FIRST CHECK THE ANSWER ON THE ANSWER LINE</b><br/> <b>If answer = 319 (K) award 3 marks</b></p> <p><math>\Delta S_{\text{sys}} = \text{products} - \text{reactants} \checkmark</math></p> <p><math>= 213.6 + (2 \times 192.3) - 69.9 - 173.9</math><br/> <math>= (+) 354.4 \checkmark</math></p> <p>temp = <math>113000/354.4</math><br/> <math>318.8 \text{ K} \checkmark</math></p>                                                                                                                                     | 3 (AO2.6<br>× 3)                           | <p>ALLOW 2 or more sf</p> <p>ALLOW ecf on incorrect <math>\Delta S_{\text{sys}}</math><br/>           Second mark subsumes first<br/>           354.4 gains 2 marks</p>                                                                                                                                                                                               |
|          |   | ii | <p><math>4\text{NO} + 4\text{NH}_3 + \text{O}_2 \rightarrow 4\text{N}_2 + 6\text{H}_2\text{O}</math> OR<br/> <math>2\text{NH}_3 + \text{NO} + \text{O}_2 \rightarrow 1\frac{1}{2} \text{N}_2 + 3\text{H}_2\text{O} \checkmark</math></p>                                                                                                                                                                                                                                                                                        | 1 (AO2.1)                                  | <p>ALLOW halves / multiples<br/>           IGNORE state symbols</p>                                                                                                                                                                                                                                                                                                   |
|          | b |    | <p>On short journeys the engine has not yet reached high temperature <math>\checkmark</math></p> <p>(Equation 31.1 is) <u>endothermic</u> so (position of) eqm will be on the left <math>\checkmark</math></p> <p>Less ammonia available to remove oxides of nitrogen <math>\checkmark</math></p> <p>At lower temp the <u>rate</u> of formation of <u>ammonia</u> will be slower <math>\checkmark</math></p>                                                                                                                    | 4 (AO3.1)<br>(AO2.5)<br>(AO3.1)<br>(AO2.5) | ORA                                                                                                                                                                                                                                                                                                                                                                   |
|          | c |    | <p><b>FIRST CHECK THE ANSWER ON THE ANSWER LINE</b><br/> <b>If answer = <math>0.67 \text{ dm}^6 \text{ mol}^{-2}</math> award 4 marks</b></p> <p>Expression for <math>K_c \checkmark</math></p> <p>Eqm conc of hydrogen = <math>3 \text{ (mol dm}^{-3}\text{)}</math> <b>AND</b><br/>           Eqm conc of nitrogen = <math>2 \text{ (mol dm}^{-3}\text{)}</math> <math>\checkmark</math></p> <p><math>(K_c = 6^2/2 \times 3^3) = 0.67 \checkmark</math></p> <p>units <math>\text{dm}^6 \text{ mol}^{-2} \checkmark</math></p> | 4 (AO2.6<br>× 4)                           | <p>ALLOW one or more sf.</p> <p>ALLOW ecf on incorrect <math>[\text{N}_2]</math> and <math>[\text{H}_2]</math><br/>           MP1 expression, MP2 concs of both, MP3 evaluation, MP4 units<br/>           If an expression for <math>K_c</math> contains only numbers, it must be clear which substance they relate to for MP1</p> <p>ALLOW units in either order</p> |
|          |   |    | <b>Total</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>12</b>                                  |                                                                                                                                                                                                                                                                                                                                                                       |

### Mark Scheme

| Question |   |     | Answer/Indicative content                                                                                                                                                                                                                                                                                                                                                                                                   | Marks            | Guidance                                                                                                        |
|----------|---|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------------------------------------------------------------------------------------------------------|
| 6        | a |     | (Chlorine and bromine are) toxic ✓                                                                                                                                                                                                                                                                                                                                                                                          | 1 (AO1.1)        | Flammable is <b>CON</b> ,<br><b>IGNORE</b> other correct statements e.g<br>volatile                             |
|          | b | i   | Orange / brown solution forms ✓                                                                                                                                                                                                                                                                                                                                                                                             | 1 (AO1.1)        | <b>IGNORE</b> starting colour if green /<br>colourless/yellow<br><b>NOT</b> Red                                 |
|          |   | ii  | $\text{Cl}_2 + 2\text{Br}^- \rightarrow 2\text{Cl}^- + \text{Br}_2$ ✓                                                                                                                                                                                                                                                                                                                                                       | 1 (AO1.1)        | <b>IGNORE</b> state symbols                                                                                     |
|          |   | iii | Chlorine better able to attract electrons<br>than bromine / Cl better oxidising agent so<br>removes electrons from Br ✓                                                                                                                                                                                                                                                                                                     | 1 (AO1.1)        | Must be comparative                                                                                             |
|          |   | iv  | <b>FIRST CHECK THE ANSWER ON THE<br/>ANSWER LINE</b><br>If answer = $5.70 \times 10^4 \text{ (dm}^3\text{)}$ award 4<br>marks<br><br>Volume of water electrolysed = $1000/1.24$<br>= $806.45\text{dm}^3$ ✓<br><br>Moles of $\text{Cl}^-$ ions = $806.45 \times 208/35.5 =$<br>$4725.12$ ✓<br><br>Volume of chlorine = $4725.12 \times 24/2$<br>= $56701 \text{ dm}^3$ ✓<br><br>= $5.70 \times 10^4 \text{ (dm}^3\text{)}$ ✓ | 4 (AO2.6<br>× 4) | <b>ALLOW</b> 2 or more sf<br>57000,<br>$1.13 \times 10^5$ ,<br>$8.72 \times 10^4$<br>score 3 marks.             |
|          | c | i   | Simple molecules with weak pd-pd forces /<br>intermolecular bonds between ✓                                                                                                                                                                                                                                                                                                                                                 | 1 (AO2.5)        | If the type of imb is specified, it must be pd-<br>pd.<br>Must mention molecules or intermolecular              |
|          |   | ii  | $\text{HCl} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{Cl}^-$ ✓                                                                                                                                                                                                                                                                                                                                          | 1 (AO1.2)        | <b>ALLOW</b> $\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$<br><b>NOT</b> eqm sign                           |
|          | d | i   | Oxidation states of bromine <b>-1 AND 0</b> ✓<br><br>Oxidation states of S <b>+6 AND +4</b> ✓                                                                                                                                                                                                                                                                                                                               | 2 (AO1.2<br>× 2) | <b>IGNORE</b> numbers in other boxes consider<br>as working.<br>Ox states must have signs before the<br>number. |
|          |   | ii  | $2\text{HBr} + \text{H}_2\text{SO}_4 \rightarrow \text{Br}_2 + \text{SO}_2 + 2\text{H}_2\text{O}$ ✓                                                                                                                                                                                                                                                                                                                         | 1 (AO1.2)        | <b>IGNORE</b> state symbols                                                                                     |
|          |   |     | <b>Total</b>                                                                                                                                                                                                                                                                                                                                                                                                                | <b>13</b>        |                                                                                                                 |

# Mark Scheme

| Question |   |     | Answer/Indicative content                                                                                                                                                                                                                                         | Marks            | Guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|----------|---|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7        | a |     |  <p>ten electrons around P atom / eight electrons around P atom if clear that lone pair from P are used to form a dative covalent bond to one O atom ✓</p> <p>rest correct ✓</p> | 2<br>(AO2.5 × 2) | <p>IGNORE minus sign<br/>ALLOW 'extra' electron on single bonded O to be the same symbol or different from the rest of the electrons on that O.<br/>Must be clear that only five electrons are from P atom.</p> <p><b>Examiner's Comments</b><br/>Most candidates scored at least 1 mark in this part as they correctly identified the 8 or 10 electrons surrounding the P atom, but then did not complete the diagram fully as they did not make ensure that each oxygen atom had a full outer shell of electrons.</p> |
|          | b |     | <p>mol P = <math>52 \times 2/142 = 0.73</math> AND mol K = <math>34 \times 2/94.2 = 0.72</math> ✓</p> <p>Ratio is about 1:1 as in <math>\text{KH}_2\text{PO}_4</math> ✓</p>                                                                                       | 2<br>(AO2.6 × 2) | <p>ALLOW <math>52/142 = 0.365</math> AND <math>34/94.2 = 0.36</math> for MP1</p>                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|          | c | i   | <p><math>\text{HPO}_4^{2-}</math> AND proton acceptor ✓</p>                                                                                                                                                                                                       | 1<br>(AO1.1)     | <p><b>Examiner's Comments</b><br/>This question was then developed to test candidates' knowledge and understanding of buffers. In (i), while most candidates could state that a base is defined as a proton acceptor, they often did not identify the correct species from the equation given. In parts (ii) and (iii) these candidates carried out the required calculations successfully, often scoring full marks.</p>                                                                                               |
|          |   | ii  | <p>7.2..... ✓</p>                                                                                                                                                                                                                                                 | 1<br>(AO1.2)     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|          |   | iii | <p><b>FIRST CHECK THE ANSWER ON ANSWER LINE</b><br/>If answer = 5.1 award 2 marks</p> <p><math>[\text{H}^+] (= \sqrt{6.2 \times 10^{-8} \times 1.0 \times 10^{-3}}) = 7.87 \times 10^{-6} \text{ (mol dm}^{-3}\text{)} \checkmark</math></p> <p>pH = 5.1 ✓</p>    | 2<br>(AO2.2 × 2) | <p>ALLOW ecf provided '<math>[\text{H}^+] =</math>' or '<math>\text{H}^+ =</math>' is shown<br/>AND value is <math>&gt; 10^{-7}</math> and <math>&lt; 10^{-4}</math></p>                                                                                                                                                                                                                                                                                                                                                |

### Mark Scheme

| Question |   |     | Answer/Indicative content                                                                                                                                                                                                                                                                                                                                                                                                  | Marks            | Guidance                                                                                                                                                                                                                                                                                                                  |
|----------|---|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|          | d |     | $\text{NH}_4^+ \rightleftharpoons \text{NH}_3 + \text{H}^+$ OR $\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{NH}_3 + \text{H}_3\text{O}^+$ ✓<br><br>Acid / $\text{H}^+$ / $\text{H}_3\text{O}^+$ (from $\text{KH}_2\text{PO}_4$ ) moves equilibrium (position) to left ✓                                                                                                                                    | 2<br>(AO2.7 × 2) | ALLOW equilibrium the other way round (and the corresponding 'right' in MP2)<br><br><u>Examiner's Comments</u><br>However, in this part, where the concept of buffers and equilibria was tested, many candidates did not score many marks. The most common omissions were not giving an appropriate equilibrium equation. |
|          | e |     | <b>FIRST CHECK THE ANSWER ON ANSWER LINE</b><br><b>If answer = 69 (g) award 4 marks</b><br><br>Value of $[\text{H}^+]$ : $3.16 \times 10^{-7}$ ✓<br><br>Rearrangement of eqn: $[\text{H}_2\text{PO}_4^-] = [\text{H}^+][\text{HPO}_4^{2-}] / K_a$ ✓<br><br>$[\text{H}_2\text{PO}_4^-] = 3.16 \times 10^{-7} \times 0.1 / 6.2 \times 10^{-8}$ OR 0.51 ✓<br><br>mass $\text{KH}_2\text{PO}_4 = (0.51 \times 136) = 69$ (g) ✓ | 4<br>(AO2.8 × 4) | ALLOW 2 or more sf<br><br>ALLOW ecf throughout                                                                                                                                                                                                                                                                            |
|          | f | i   | Equilibrium will move to left (AW) ✓<br><br>$[\text{H}^+]$ only restored / unchanged (AW) if $[\text{H}_2\text{PO}_4^-]$ is large ✓                                                                                                                                                                                                                                                                                        | 2<br>(AO3.1 × 2) | <u>Examiner's Comments</u><br>However, in this part, where the concept of buffers and equilibria was tested, many candidates did not score many marks. The most common omissions were failing to explain why the equilibrium moves to the left in (i).                                                                    |
|          |   | ii  | (Student is correct (AW) AND) HCl strong (acid) so all reacts / dissociates/ionises ✓                                                                                                                                                                                                                                                                                                                                      | 1<br>(AO3.1)     |                                                                                                                                                                                                                                                                                                                           |
|          |   | iii | <b>FIRST CHECK THE ANSWER ON ANSWER LINE</b><br><b>If answer = 0.7 award 2 marks</b><br><br>$[\text{H}^+] (= 0.05 \times 0.01/1000) = 5 \times 10^{-7}$ ✓<br><br>pH change = $7 - 6.3 = 0.7$ ✓                                                                                                                                                                                                                             | 2<br>(AO2.8 × 2) | ALLOW ecf                                                                                                                                                                                                                                                                                                                 |
|          |   |     | <b>Total</b>                                                                                                                                                                                                                                                                                                                                                                                                               | <b>19</b>        |                                                                                                                                                                                                                                                                                                                           |