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Examiners' report

GATEWAY SCIENCE COMBINED SCIENCE A

J250

For first teaching in 2016

J250/09 Summer 2022 series

Version 1

ocr.org.uk/science

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers are also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Advance Information for Summer 2022 assessments

To support student revision, advance information was published about the focus of exams for Summer 2022 assessments. Advance information was available for most GCSE, AS and A Level subjects, Core Maths, FSMQ, and Cambridge Nationals Information Technologies. You can find more information on our website.

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Paper 9 series overview

Welcome to the report for this Higher tier Chemistry component assessing topics C1 to C3 (and CS7) of the Gateway Combined Science qualification. It is pleasing to see candidates being given the opportunity to demonstrate their knowledge in examinations once again.

Centres have clearly put a huge amount of effort into getting candidates ready for the examination series through the difficult times of the previous 2 years. I hope to guide you through areas of the specification where candidates performed well and those areas where common misconceptions occurred.

Candidates who performed well on the paper tended to have a good grasp of atomic structure and types of bonding. Being able to identify covalent, ionic and metallic bonding characteristics was a key area where demonstrating understanding led to success.

Some candidates appeared to struggle with AO3 style questions where they had to apply their knowledge to different situations, particularly where the command words asked candidates to explain using their own scientific ideas. Understanding the command words for each question is an essential part of the preparation for the examinations. Without this preparation candidates may struggle to access the question and will be limited in how they demonstrate their knowledge and understanding of the specification being assessed.

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
• Expressed their ideas about covalent bonding clearly • Described the transfer of electrons in ionic bonding • Identified errors in an electrolysis set up and suggested improvements • Added their scientific ideas to explain trends in data • Described metallic bonding • Wrote a balanced symbol equation for a metal reacting with water • Calculated accurately (e.g. the number of moles and the concentration of solution) • Explained pH changes during a neutralisation reaction • Used ideas about oxidation and reduction to explain what is happening in a reaction	• Mixed up ideas of covalent bonds and intermolecular forces • Found it difficult to express their ideas about the properties of large covalent molecules such as fullerenes • Explained their ideas about improvements they could make to electrolysis circuits • Drew a metallic bonded structure and described its properties • Related the trends in properties of group 7 halides to the properties of simple covalent molecules • Constructed a balanced symbol equation • Used a calculated value for moles to calculate concentration • Described a neutralisation reaction in terms of concentration of hydrogen ions and pH changes

Section A overview

Candidates performed well in Questions 1-3. Questions 4-6 and Questions 9-10 were each answered correctly by roughly half of candidates. Questions 7 and 8 were more challenging, with a much larger proportion of candidates not being able to identify the correct answer.

Multiple choice questions can be time consuming and difficult to answer. Teachers need to train candidates to work through this style of questions in the same way they would prepare candidates for other sections of the exam.

Question 1

1 A molecule of glucose has the molecular formula $C_6H_{12}O_6$.

What is the **empirical formula** of glucose?

A CHO

B CH_2O

C $C_6H_{12}O_6$

D $(CO)_6H_{12}$

Your answer ☐ **[1]**

The majority of candidates could identify the empirical formula of glucose.

Question 2

2 The equation shows the reaction between carbon dioxide, CO_2, and hydrogen, H_2.

$$CO_2 + H_2 \rightarrow CO + H_2O$$

What has been **reduced** in this reaction?

A CO

B CO_2

C H_2

D H_2O

Your answer ☐ **[1]**

A large number of candidates could determine that carbon dioxide had been reduced.

Question 3

3 Which statement describes the **isotopes** of an element?

A Atoms that have different numbers of protons but the same number of electrons.

B Atoms that have different numbers of protons but the same number of neutrons.

C Atoms that have the same number of protons but different numbers of electrons.

D Atoms that have the same number of protons but different numbers of neutrons.

Your answer ☐ **[1]**

Candidates had been well trained to identify the similarities and differences in the number of protons and neutrons in isotopes.

Question 4

4 Which substance is an example of a **formulation**?

A A macromolecule

B A metal

C An alloy

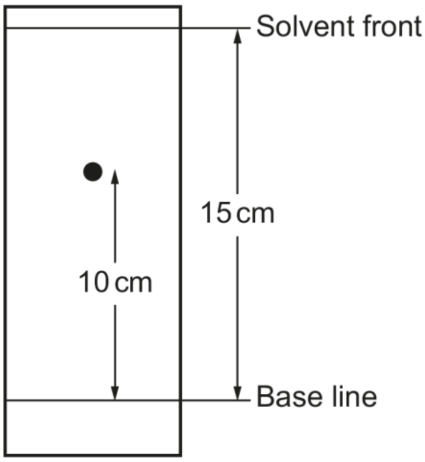
D An ionic compound

Your answer ☐ **[1]**

Roughly half of candidates could define a formulation as an alloy.

Question 5

5 The diagram shows a chromatogram produced by paper chromatography.



What is the R_f value?

A –10

B –5

C 0.67

D 1.5

Your answer [1]

D was commonly incorrectly given as a response, perhaps because candidates had divided the numbers the wrong way around. An R_f value should be less than 1 and cannot be a negative number.

Question 6

6 The table shows some information about four different acids.

Acid	Number of particles per cm^3 of acid solution	Degree of ionisation (%)
A	high	1
B	low	1
C	high	100
D	low	100

Which acid is a **dilute** solution of a **strong** acid?

Your answer ☐ **[1]**

Understanding the difference between concentration and strength was assessed here. Around half of candidates identified acid D as the one with a low concentration and a high strength. There was no obvious pattern in the incorrect responses.

Question 7

7 The ionic equation shows the reaction of chlorine, Cl_2, with sodium bromide, NaBr.

$Cl_2 + 2Na^+ + 2Br^- \longrightarrow Br_2 + 2Na^+ + 2Cl^-$

What is the **simplest** ionic equation for this reaction?

A $Cl_2 + 2NaBr \longrightarrow Br_2 + 2NaCl$

B $Cl_2 + Na^+ + Br^- \longrightarrow Br_2 + Na^+ + Cl^-$

C $Cl_2 + Br^- \longrightarrow Br_2 + Cl^-$

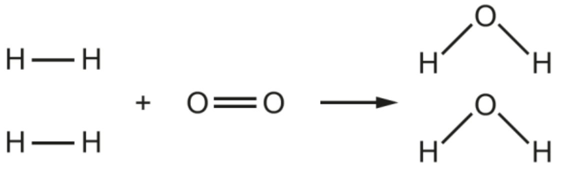
D $Cl_2 + 2Br^- \longrightarrow Br_2 + 2Cl^-$

Your answer ☐ **[1]**

Candidates found this question on ionic equations challenging. The majority of candidates chose equation C (an unbalanced ionic equation) or equation A (a balanced equation that is not ionic).

Question 8

8 The diagram shows the reaction of hydrogen, H_2, and oxygen, O_2, to make water, H_2O.



The energy required to break all the H–H and O=O bonds is 1368 kJ / mol.
The energy change for the reaction is –484 kJ / mol.

What is the bond energy for the **O–H** bond?

A 463 kJ / mol

B 884 kJ / mol

C 926 kJ / mol

D 1852 kJ / mol

Your answer **[1]**

The majority of candidates found this question a challenge. Often C was chosen suggesting that some candidates calculated the bond energy for each molecule or didn't remember that 1852 kJ / mol was associated with the production of 2 water molecules.

Question 9

9 A solution has a pH of 3.

The solution is diluted with water by a factor of 1000.

What is the pH of the solution **after** dilution?

A 2

B 4

C 5

D 6

Your answer **[1]**

The majority of candidates found this question challenging.

Question 10

10 What is the definition of the **mole**?

A One mole contains 1 g of atoms.

B One mole contains 6.022×10^{23} particles.

C One mole is equal to the relative atomic mass of an element.

D One mole is the number of atoms contained in one molecule.

Your answer ☐ **[1]**

Where candidates gave an incorrect response, there was no real pattern in their answers. Around half of candidates correctly identified B as the definition of a mole.

Section B overview

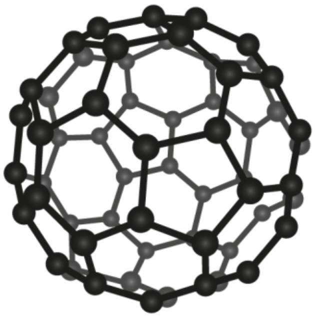
This section contains some longer answer questions. Candidates who read the full stem of the question and referred back to diagrams or tables of data when preparing their answers, tended to provide stronger responses. Common misconceptions have been highlighted. Candidates varied significantly in their ability. The lack of exam readiness was evident from the start of the section and seem to make it difficult for some candidates to interpret what the question was asking them to do.

Question 11 (a) (i)

11 Fullerenes are allotropes of carbon that have many uses.

Fig. 11.1 shows a molecule of a fullerene.

Fig. 11.1



(a) (i) Which group of allotropes contain this fullerene?

Tick **one** (✓) box.

Inorganic ☐

Organic ☐

Physical ☐

[1]

A large number of candidates found it a challenge to identify organic as the group to which fullerenes belong.

Question 11 (a) (ii)

(ii) What is the approximate size of a molecule of this fullerene?

Tick **one** (✓) box.

1×10^{-15} m ☐

1×10^{-10} m ☐

1×10^{-5} m ☐

[1]

This question gave a mix of answers with around half of the candidates correctly identifying the size of the fullerene molecule.

Question 11 (b) (i)

(b) The carbon atoms in fullerenes are joined by covalent bonds.

(i) Explain how two atoms of carbon form a covalent bond.

....

....

....

.... **[2]**

Most candidates could identify the fact that a covalent bond occurs by the sharing of electrons. Fewer candidates explained how just one covalent bond forms. Several candidates described the sharing of 4 electrons from each carbon atom. This may be true for carbon in a compound such as methane, but in this question they were asked about 'a' covalent bond.

Question 11 (b) (ii)

(ii) How many covalent bonds does one atom of carbon form in a molecule of fullerene, as shown in **Fig. 11.1**?

.... **[1]**

This question was well answered with the majority of candidates scoring the mark.

Question 11 (c)

(c) The model used to show the molecule of fullerene in **Fig. 11.1** has limitations.

The table shows some statements about the model.

Which statements about this model are **true**, and which are **false**?

Tick **one** (✓) box in each row.

	True	**False**
It shows the length of the covalent bonds.		
It shows the size of the carbon atoms.		
It shows the three-dimensional shape of the molecule.		

[2]

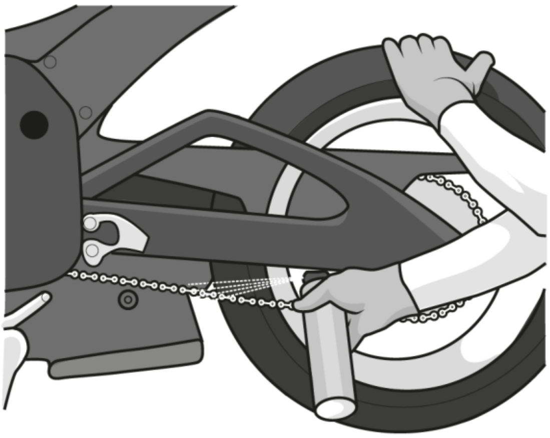
Most candidates scored 2 marks on this question, and almost all candidates scored at least 1 mark. Some candidates seemed unsure about the length of the covalent bond and the size of the carbon atom.

Question 11 (d) (i)

(d) Fullerenes can be used as lubricants. Lubricants reduce the friction between moving parts.

Fig. 11.2 shows a lubricant being sprayed onto the chain of a motorbike.

Fig. 11.2



(i) Explain why fullerenes can be used as lubricants.

Use ideas about the structure and bonding of the fullerene shown in **Fig. 11.1** in your answer.

....

....

....

.... **[2]**

Misconception

The difference between covalent bonds and intermolecular forces was misunderstood. Candidates found it difficult to explain high melting points and often talked about breaking the covalent bonds within the molecule rather than the intermolecular forces.

Centres could look to resources such as these BEST materials to address misconceptions with this kind of question.

Answers to this question often included lots of misconceptions about bonding. Candidates often described 'layers sliding over each other', yet the molecule is spherical and has no layers. In this case, this is a good lubricant because the molecules of fullerene slide over each other. Candidates found it a challenge to evaluate their knowledge from other allotropes of carbon such as graphite and apply it into this situation. Only a small number of candidates could correctly describe the weak intermolecular forces which allowed this sliding of the molecules to occur.

Question 11 (d) (ii)

(ii) A lubricant may need to be used at high temperatures.

Explain why fullerenes can be used at high temperatures.

Use ideas about the structure and bonding of the fullerene shown in **Fig. 11.1** in your answer.

....

....

....

....

....

.... **[3]**

A significant number of candidates scored at least 1 mark on this question. The most common number of marks given was 1. Candidates generally identified the covalent bonding. The identification of 'strong' or 'many' covalent bonds seemed to be the challenging aspect of this question. Again there were misconceptions evident surrounding covalent bonds and intermolecular forces. Often the two were confused.

Exemplar 1

they have strong intermolecular forces meaning it needs more energy to break the bond between the carbons

This candidate has discussed the bonds between carbon atoms as intermolecular forces rather than covalent bonds. This kind of response was commonly seen. This candidate scored 0 marks as they have confused the overcoming of intermolecular forces to melt a substance, with the breaking of the covalent bonds between the carbon atoms.

Question 12 (a)

12 Potassium chloride, KCl, is an ionic compound.

It is made from potassium ions, K^+, and chloride ions, Cl^-.

(a) Explain why potassium is found in Group 1 of the Periodic Table.

Use ideas about the arrangement of electrons in an atom of potassium.

....

.... **[1]**

Most candidates could recall that there is one electron in the outer shell of a potassium atom.

Question 12 (b)

(b) Explain how an atom of potassium reacts with an atom of chlorine to make potassium chloride.

....

....

.... **[2]**

Misconception

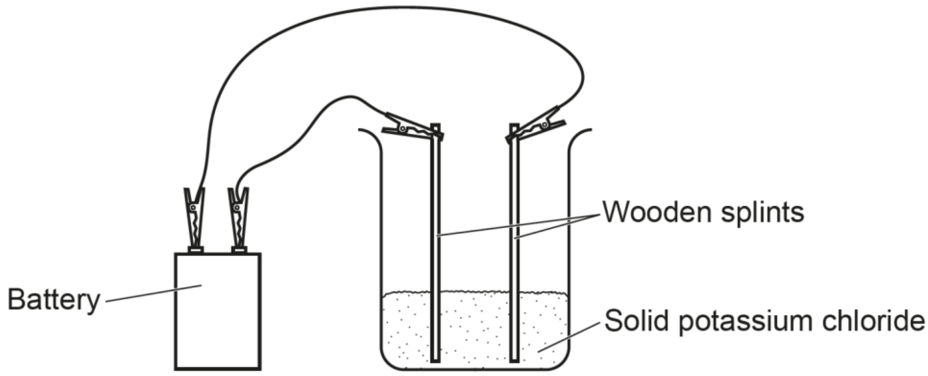
Covalent and ionic bonding was confused in this question. Candidates talked about potassium losing an electron but then later discussed it sharing electrons to make a full outer shell.

This question was generally well answered. Candidates who scored here usually scored both marks. There were lots of examples of unclear communication and contradictions (for example, where both ionic and covalent ideas were put forward). There was a wide range of approaches to expressing the information here. Candidates could simply write 'potassium transfers one electron to chlorine' to achieve 2 marks.

Question 12 (c)

(c) A student electrolyses potassium chloride.

The diagram shows the equipment they use.



The student's experiment does **not** work.

Describe and explain **two** ways the student could change the experiment to make it work.

1 ....

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....

2 ....

....

....

[4]

The command words for this question are 'describe' and 'explain'. A large number of candidates were given 2 or 3 marks on this question because they could describe the change they would make, but often forgot to explain why this change would now make the experiment work. The most common omission was the idea of using a liquid or solution to allow there to be ions that are free to move.

Question 12 (d)

(d) In the successful electrolysis of potassium chloride, potassium is made at the cathode.

Explain how potassium atoms are made from potassium ions.

....

....

....

....

.... **[3]**

This question expected the candidates to recall that positive potassium ions would be attracted to the cathode where they would gain one electron. A significant proportion of candidates were unable to score due to the contradictions they made when discussing sharing electrons rather than ions moving and collecting electrons from the positive terminal. Some candidates wisely wrote a balanced half equation which was enough to score 2 out of the 3 marks available in the question.

Question 13*

13* Hydrogen can form compounds with the Group 7 elements. These compounds are simple covalent molecules.

For example,

hydrogen + chlorine → hydrogen chloride

$H_2 + Cl_2 \rightarrow 2HCl$

When simple covalent molecules are heated, they thermally decompose back into their elements.

For example,

hydrogen chloride → hydrogen + chlorine

$2HCl \rightarrow H_2 + Cl_2$

Tables 13.1 and **13.2** show information about the compounds formed from hydrogen and some Group 7 elements.

Table 13.1

Compound	Structure of molecule	Boiling point (°C)	Temperature needed for thermal decomposition (°C)
hydrogen chloride	H–Cl	–85	over 1500
hydrogen bromide	H–Br	–67	over 1000
hydrogen iodide	H–I	–35	over 200

Table 13.2

Compound	Structure of molecule	Size of molecule (pm)	Strength of covalent bond (kJ/mol)
hydrogen chloride	H–Cl	127	431
hydrogen bromide	H–Br	141	366
hydrogen iodide	H–I	161	299

Describe the trends in the properties of the compounds in **Table 13.1**.

Explain these trends using information from **Table 13.2** and ideas about the structure and bonding of simple covalent molecules.

....

....

....

....

....

.... **[6]**

The most common mark given for this question was 2. Candidates appeared to engage with the command word 'describe' but not with the 'explain' section of the question. Candidates could quote trends from the tables but struggled to explain the trends using their own scientific ideas. The ideal links were firstly between boiling point increasing and increasing size of the molecule. This should then have been explained using ideas about intermolecular forces, as greater intermolecular forces exist with larger molecules therefore more energy is needed to overcome these forces, hence the increase in boiling points. The second link was between the thermal decomposition and the strength of the covalent bond. As you go down the table the strength of the covalent bond decreases. This can be explained by the increased distance between the nucleus and outer electron leading to weakened attraction. This means the thermal decomposition of the molecule requires less energy so the value shown in the table gets smaller as you go down the table (or group). These were not the links that candidates made. Candidates offered all possible links and then struggled to explain these with correct science. For example, if the candidate linked boiling points to covalent bond strength, they then might try to explain this using either intermolecular forces or covalent bonding, and neither would be appropriate to use.

Some candidates had very clear ideas which they communicated well, using well developed lines of reasoning which were logical and well structured.

Exemplar 2

As the size of the molecule increases the ~~melt~~ boiling point does as well as it is harder to break the bonds between the molecules.

However, the covalent bonds (~~the~~ bonds within molecules) also weaken meaning ~~it is~~ the temperature needed for thermal decomposition is lower.

This candidate has identified the appropriate trends in the data and has offered some explanation for the trend in boiling points by identifying intermolecular forces. They have offered no explanation for why the covalent bonds weaken This is a Level 2 response and scores 4 marks as the response is presented with some structure.

Exemplar 3

-hydrogen chloride had the smalest size molecule but had the strongest covalent bond Hydrogen iodide had the biggest size molecule but the ~~stro~~ weakest strength of covalent bond. a diffrence from ~~of~~ ~~stro~~ strongest to weakest was. 132kJ/mol. A simple covalent molecules are Hydrogen and ~~banding~~ strongest covalent bonding is Hydrogen chloride. Hydrogen bromide was in the middle of both hydrogen chloride and iodide. hydrogen chloride had the strongest bonding and is a non metal. **[6]**

This candidate had identified some trends in the tables but has not given any scientific explanation for these trends. The candidate has linked the size of the molecule to the strength of the covalent bond but offered no reasons as to why this is the case. Without any scientific explanation the candidate can't move to Level 2. This is a Level 1 response and the candidate scored 2 marks.

Question 14 (a)

14 Calcium is a metal found in Group 2 of the Periodic Table.

(a) Draw the arrangement of electrons in an atom of calcium.

[1]

The majority of candidates could draw the electron arrangement of calcium. Where there were errors it was often only drawing 3 shells instead of 4 so only 12 electrons were drawn.

Question 14 (b)

(b) Calcium is a metal which can conduct electricity.

Describe the structure and bonding in a metal **and** explain why metals can conduct electricity.

You can include a diagram in your answer.

....

....

....

....

....

.... **[4]**

This question was generally answered well. Several marks could be achieved by drawing a suitable diagram. The term 'delocalised electrons' was well used in drawings. The understanding of the term delocalised was lacking when it came to explaining the idea of free moving electrons

Question 14 (c) (i)

(c) Calcium reacts with water to form a solution of calcium hydroxide, $Ca(OH)_2$, and hydrogen.

(i) Write the **balanced symbol** equation for the reaction of calcium with water.

Include **state symbols** in your equation.

.... **[3]**

The majority of candidates made simple mistakes with formula. The most common mistake was giving the formula of hydrogen as 2H instead of H_2. This is an area for improvement for the future series as it a common and recurring error. State symbols were rarely added despite the prompting in the stem of the question.

Question 14 (c) (ii)

(ii) A solution of calcium hydroxide is also called **limewater**.

Name the gas limewater is used as a test for.

.... **[1]**

A significant number of candidates could recall that the test using lime water is for carbon dioxide.

Question 14 (d) (i)

(d) 250 cm^3 of a solution contains 1.88 g of calcium hydroxide, $Ca(OH)_2$.

(i) Calculate the **number of moles** in 1.88 g of calcium hydroxide.

Give your answer to **2** significant figures.

Relative atomic mass (A_r): H = 1.0 O = 16.0 Ca = 40.1

Number of moles of calcium hydroxide = ... **[3]**

The majority of candidates scored at least 1 mark here. The most common number of marks was 3. Where 2 marks were given, it was usually for incorrectly calculating the relative molecular mass (57.1 instead of 74.1) and then completing the calculation and giving an answer to an appropriate number of significant figures. In such a case the 'error carried forward' principle has been applied as an error was made at the beginning of the calculation. Where only one mark was scored then it was usually for the correct calculation of the M_r of calcium hydroxide to be 74.1.

Question 14 (d) (ii)

(ii) Use your answer to part **(d)(i)** to calculate the concentration of calcium hydroxide in the solution formed.

Give your answer in mol / dm^3.

Concentration of solution = ... mol / dm^3 **[2]**

Very few candidates scored marks on this question despite there being the possibility to carry an error forward from the previous question. Calculating concentration given the moles and volume should just require the division of moles by volume. The volume must be changed into dm^3. This caused problems for some candidates.

Question 14 (e) (i)

(e) A student adds an excess of dilute hydrochloric acid, HC*l*, to a solution of calcium hydroxide, $Ca(OH)_2$.

(i) Write the **balanced ionic** equation for the reaction of dilute hydrochloric acid and a solution of calcium hydroxide.

.... **[1]**

Almost no candidates scored this mark. A variety of attempts were made to write equations but they seemed to miss the point that this was a neutralisation reaction. The ionic equation is much simpler than the candidates tried to make it. The candidates needed to make the link to this being an acid/alkali reaction which produces water (and a salt). They should then focus on the ions present that change in the reaction and remove the spectator ions. Full formulae were often given and candidates seemed to struggle to appreciate what an ionic equation should contain.

Question 14 (e) (ii)

(ii) Describe and explain how the pH of the solution of calcium hydroxide changes as the dilute hydrochloric acid is added until it is in excess.

....

....

....

....

....

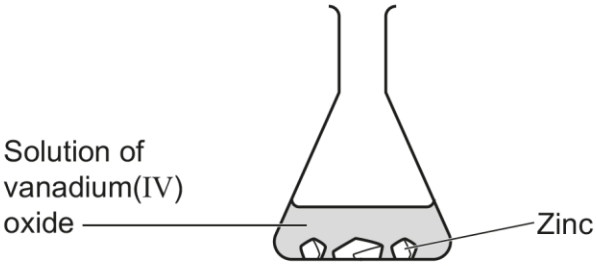
.... **[3]**

Almost no candidates scored 3 marks. As the previous question was not identified as a neutralisation reaction through an ionic equation, this was also not recognised as a neutralisation in words. Where candidates did express some understanding of neutralisation, they then struggled to express the fact that the pH dropped below 7 as the concentration of hydrogen increased.

Question 15 (a)

15 Colour changes can be used to show that oxidation and reduction happen in chemical reactions.

The diagram shows the reaction between an acidic solution of vanadium(IV) oxide and zinc.



- As the reaction happens the colour of the solution turns from **blue** to **green**.

The balanced half equation shows the reaction of vanadium(IV) oxide.

$$VO^{2+} + 2H^{+} + e^{-} \rightarrow V^{3+} + H_2O$$

(a) A student thinks that the half equation shows that **reduction** has taken place.

Describe **two** ways in which the half equation shows the student is **correct**.

1 ....

....

2 ....

....
[2]

Candidates generally scored well here as they could recall OILRIG and this was seen written down on many occasions. The problem was when candidates tried to attach the gain of electrons to a species. Often hydrogen rather than vanadium oxide was the suggested species.

Question 15 (b)

(b) This half equation shows the reaction of the zinc.

$$Zn \rightarrow \text{......} + 2e^-$$

Complete the **half equation** for the reaction. **[1]**

A significant number of candidates could identify zinc as the missing entity. Where the candidates did not score the mark, charge on the zinc ion was often misquoted as just + or was omitted completely.

Question 15 (c)

(c) The student removes the zinc from the green solution by filtration.
When they add some nitric acid to this solution it turns back from **green to blue**.

What is the role of the dilute nitric acid in this reaction?

Tick **one** (✓) box.

A base ☐

A reducing agent ☐

An oxidising agent ☐

[1]

This question was answered well. This was reflected from the candidates demonstrating a knowledge of OILRIG in the previous question.

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