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CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

APPLIED SCIENCE

Cambridge TECHNICALS

Unit 1 January 2019 series

Version 1

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. 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 can be downloaded from OCR.

Unit 1 series overview

In general, candidates performed well with this paper. Almost all candidates responded to all questions and completed the paper within the time allocated. Some used the additional page to good effect and made clear links to this page within the body of the question paper.

Many candidates were able to access all or most of the topics covered and made a good attempt to respond to the instructions provided. They appeared to be familiar with the rubric of the paper.

Candidates were clearly supported by the scaffolding available for a number of question items. This enabled them to work through the steps involved and to achieve the desired outcome. The objective format of many question items allowed a number of candidates to obtain the marks necessary to progress onto the merit level, and in some cases to achieve an overall distinction.

Candidates tended to be less successful with the 'free response' question of 6 marks. Many were limited to a marking allocation at Level 1, or at the most Level 2. The degree of analysis required for this type of question, in this case, in relation to the generation of conclusions, was somewhat challenging.

The January 2019 series for Unit 1 was set at an equal standard demonstrated in the January and June 2018 papers. Candidates performed equally well.

Question 1(a)

1 **Fig. 1.1** shows the arrangement of electrons in an atom of element **Y**.

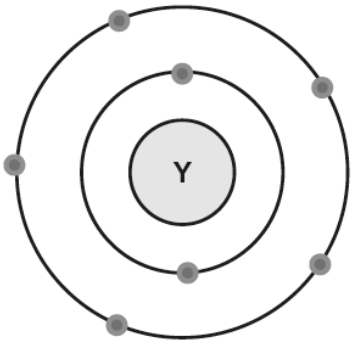


Fig. 1.1

(a) How many protons are in the nucleus of an atom of element **Y**?

Put a (ring) around the correct answer.

2 **5** **7** **8**

[1]

The majority of candidates identified the correct response of 7 protons in the nucleus. A few candidates incorrectly identified 2 protons but an alternative trend for such responses was not clear. This first question item was very accessible for candidates.

Question 1(b)

(b) **Fig. 1.2** shows the bond between two atoms of element **Y**.

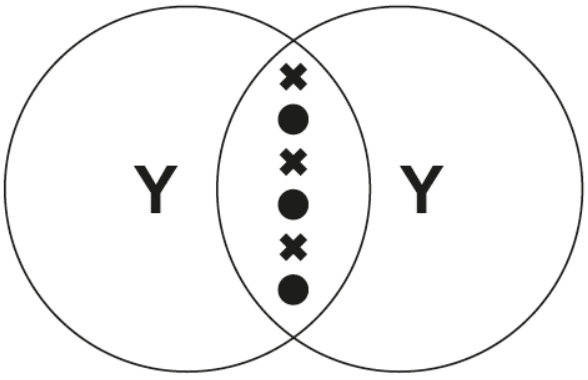


Fig. 1.2

Describe the bond between the two atoms of element **Y**.

.....

.....**[2]**

Again, this item was clearly accessible to candidates. They fully appreciated that the bond is covalent and that it is based on sharing electrons. No alternative type of incorrect response was identified.

Question 1(c)(i)

(c) (i) The distance between two nuclei of atoms of element **Y** is 3.1×10^{-10} m.

Explain why the nuclei cannot come any closer together.

.....

.....**[2]**

Although most candidates successfully identified that repulsion (or a repulsive force) is involved in this concept, many did not note that protons were involved. A common error was to refer to atoms or electrons.

Question 1(c)(ii)

(ii) What is the name of the element **Y**?

Put a (ring) around the correct answer.

Chlorine **Helium** **Nitrogen** **Oxygen**

[1]

This objective-style format enabled the majority of candidates to identify element Y as nitrogen. The most common alternative, incorrect response was chlorine.

Question 1(d)(i)

(d) The relative atomic mass of a different element, **Z**, is 24.305.

(i) What is the name of element **Z**?

Put a (ring) around the correct answer.

Calcium **Chromium** **Magnesium** **Sodium**

[1]

It was encouraging to see that almost all candidates correctly selected magnesium. A common error could not be identified for this item.

Question 1(d)(ii)

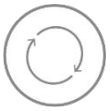
(ii) Explain why the relative atomic mass of **Z** is not a whole number.

.....

.....

.....**[2]**

This item proved to be very challenging for most candidates. Although some realised that isotopes were involved, very few referred to the average mass or nucleon number.



AfL: It is recommended that teachers and students reconsider the basic features of relative atomic mass.

Question 1(e)(i)

(e) The nuclear radius *R*, of an atom can be approximated using the formula $R = r_0 A^{1/3}$, where A is the nucleon number (atomic mass number) and $r_0 = 1.25 \times 10^{-15}$ m.

The formula can be rearranged to give: $A = \left(\frac{R}{r_0}\right)^3$

Element **W** has a nuclear radius $R = 3.55 \times 10^{-15}$ m.

(i) Calculate the nucleon number (atomic mass number) A of element **W**.

Give your answer to the nearest whole number.

nucleon number (atomic mass number) A = ...**[3]**

A number of candidates were very successful with this item and calculated the nucleon number as 23 (to the nearest whole number). Some candidates presented their final answer as 22.9; this limited them to 2 out of the 3 marks available. It is suggested that, for this type of item, candidates take particular note of the instructions given for the presentation of their response.

Misconception: A common misconception is for candidates to give the value shown on their calculator screen without considering the instruction.

Question 1(e)(ii)

(ii) Complete the half-equation to show how an atom of element **W** becomes an ion.

$W \longrightarrow W^{+} + ...$

[1]

This item enabled almost all candidates to give the correct response of e^-. An common error observed was W^-.

Question 1(f)(i)

(f) Elements in the Periodic Table show a periodic trend in atomic radius from **Li** to **F**.

(i) What trend is shown in the atomic radius from **Li** to **F**?

.....**[1]**

A number of candidates considered that the atomic radius increased, rather than decreased. It is suggested that this topic is considered further via greater familiarity of the Periodic Table.

Question 1(f)(ii)

(ii) Explain your answer to **(f)(i)**.

.....

.....

.....**[2]**

This item proved to be most challenging for many candidates. There appeared to be a lack of understanding of electron shells and/or nuclear attraction on electrons/shells. Very few candidates were able to obtain marks for this item.

Question 1(g)

(g) The relative masses and relative charges of some subatomic particles are shown in **Table 1.1**.

Subatomic particle	Relative mass	Relative charge
A	1	+1
B	1	0
C	1/1836	-1

Table 1.1

Identify subatomic particles **A**, **B** and **C** by drawing a line to the correct name for the particle.

Subatomic particle		Name
A		**Neutron**
B		**Proton**
C		**Electron**

[3]

Candidates are clearly very familiar with the characteristics of such subatomic particles. Most candidates achieved the correct pattern of interconnecting lines for this objective item. As a result, no common error can be identified.

Question 2(a)

2 Andy is investigating reactions in chemical and biological systems.

His teacher tells him that reactions are affected by a number of different factors including temperature.

(a) Andy writes some sentences about the relationship between temperature and the rate of a reaction.

Complete the sentences below using the words listed. The words can be used once, more than once or not at all.

at the same rate	**kinetic**	**slower**	**increases**	**nuclear**
faster	**heat**	**decreases**	**stays the same**	

As temperature increases the molecules move ..... and as a result, the molecules have more ..... energy.

The number of collisions that can overcome the activation energy for the reaction ..... with an increase in temperature.

[3]

The provision of the word options gave the scaffolding needed for this topic. It is apparent that candidates are familiar with the impact of temperature on biological systems. One common error related to the final sentence. Some candidates selected 'decreases' or 'stays the same' instead of the correct response, 'increases'. It would be useful for the topic of collisions to be reinforced in the future.

Question 2(b)(i)

(b) (i) Andy also investigates the effect of enzymes on the rate of reactions.

What term is used to define an enzyme?

Put a (ring) around the correct answer.

Activist	**Catalyst**	**Energy**	**Product**	**Reactant**

[1]

This topic is very familiar to candidates. The definition of an enzyme is well-understood and, as a result, almost all candidates correctly selected 'catalyst'. The only other option identified, in error, was 'activist'.

Question 2(b)(ii)

(ii) Andy looks at the graph in **Fig. 2.1** which shows the energy profile of a reaction, with and without an enzyme present.

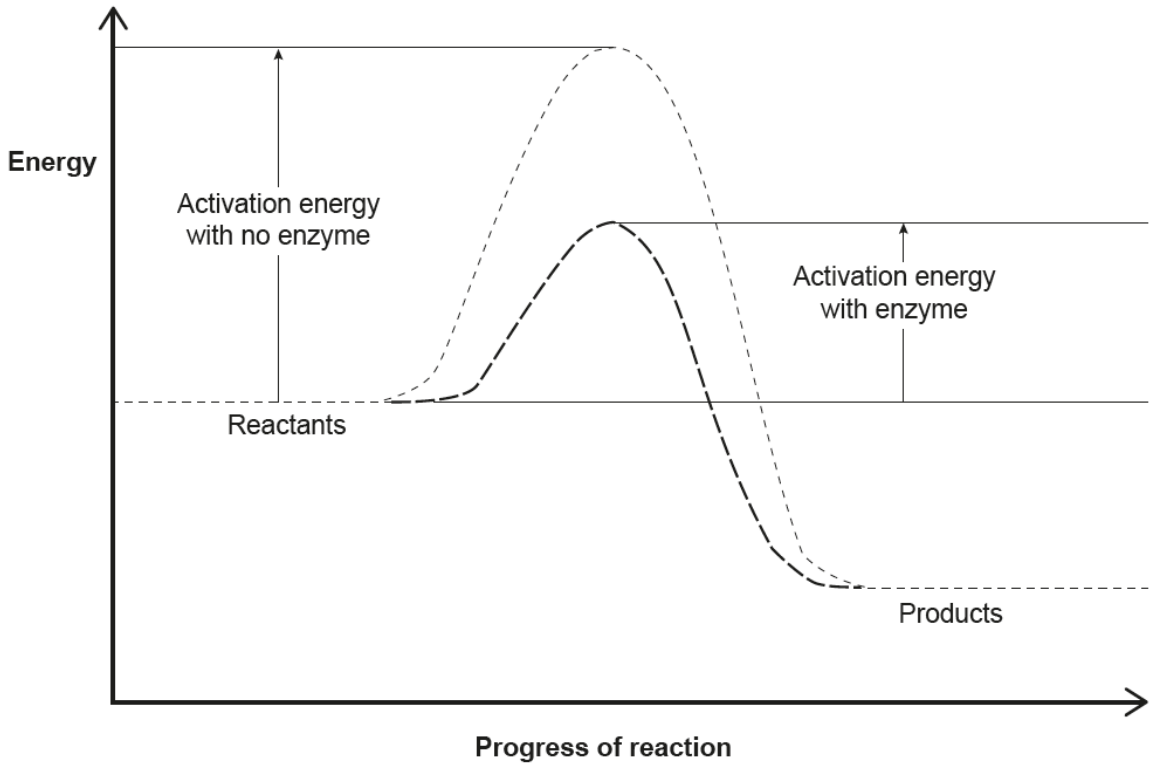


Fig. 2.1

Describe the key features of the graph shown in **Fig. 2.1**.

.....

.....

.....

.....**[4]**

The most common, correct response related to the key feature of lowering activation energy for the reaction with an enzyme. It is unfortunate that the wide range of other key features were not identified. Such factors included the energy level shared by the reactants, the energy level shared by the products and the overall loss of energy shown by the graph. Some candidates referred to the time of the reaction but this is not a feature of the graph.

Question 2(b)(iii)

(iii) Suggest **two** ways of measuring the progress of the reaction shown in **Fig. 2.1**.

1 .....

2 .....

[2]

Most candidates did not consider the number/concentration of the reactants or products as a measure. The energy level of the reactants/products could also have been included as an effective measure. A number of candidates referred to the measurement of gas released etc. but without mentioning a named reaction. Such features do not relate to the data provided in **Fig.2.1**. The data are generalised and do not consider a named reaction.

Question 2(c)

(c) The lock and key hypothesis is used to describe how enzymes work.

The hypothesis includes a number of steps.

Below is a list of the key steps but they are **not** in the correct order.

Put a number in each box to show the correct order. The first one has been done for you.

Description	Step
An enzyme/reactant complex forms.	
The products are released from the active site.	
The reactant fits into the active site of the enzyme.	**1**
The enzyme returns to its original state.	
An enzyme/product complex forms.	

[4]

Candidates often demonstrated a good understanding of the lock and key hypothesis and obtained full marks. The provision of the steps, as the basis for this objective format, clearly assisted the candidates. No clear pattern of incorrect responses was identified.

Question 3(a)(i)

3 *Cymbomonas* is a single-celled green alga. *Cymbomonas* is able to engulf bacteria.

When there is a lot of light, *Cymbomonas* carries out the process of photosynthesis.

If light levels fall, it will start to engulf bacteria and the bacteria collect in the cell vacuole.

Fig. 3.1 shows a transmission electron micrograph of *Cymbomonas*.

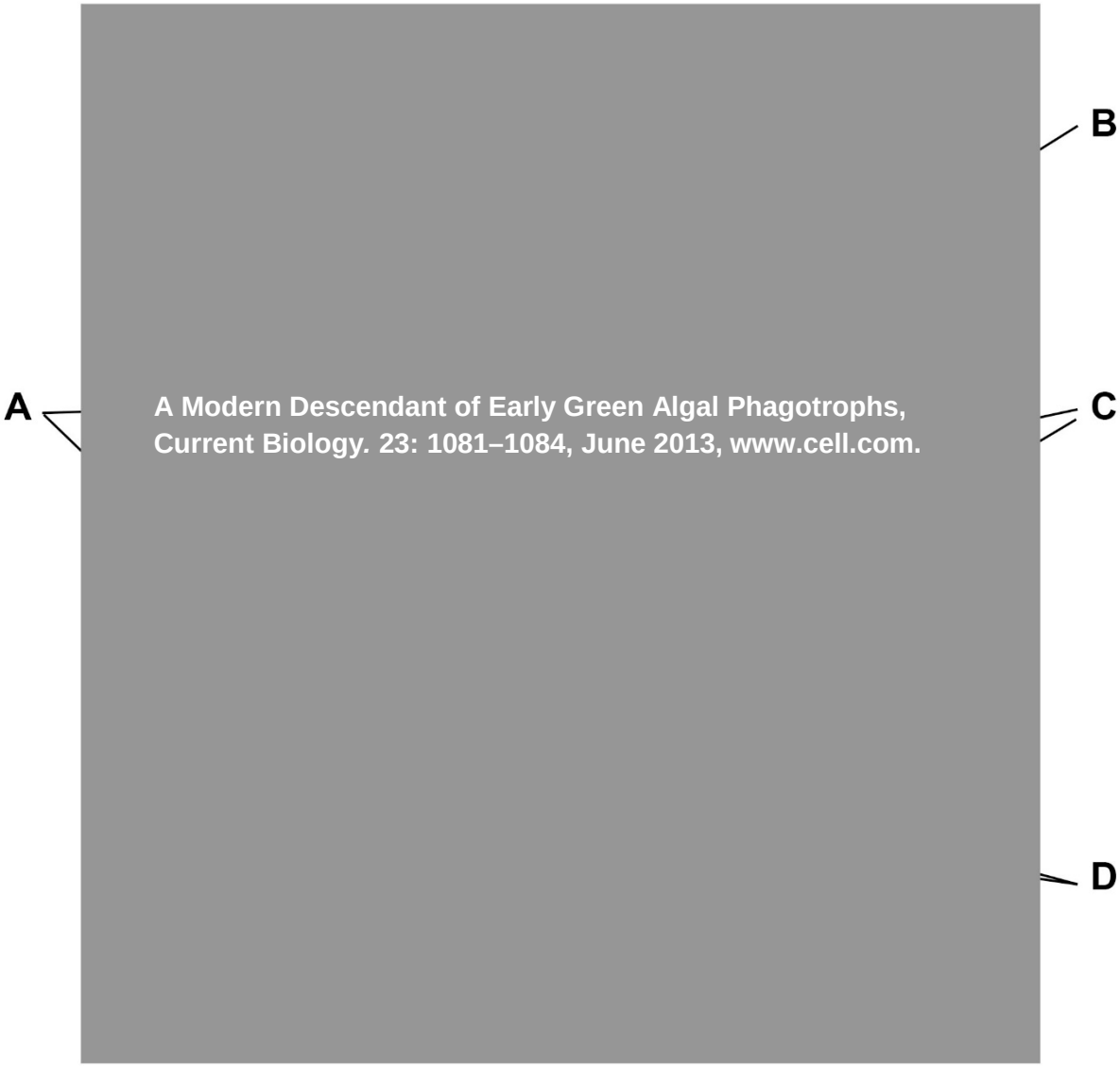


Fig. 3.1

Key

A = two parts of a single chloroplast

B = Golgi apparatus

C = bacteria inside the cell vacuole

D = mitochondria

Question 3(a)(i) continued

(a) (i) State **one** function of the Golgi apparatus in **Fig. 3.1**.

.....

.....**[1]**

Although many candidates were familiar with the role of the Golgi apparatus in the packaging or processing of materials such as proteins and lipids, a number did not have the knowledge to complete this item successfully. There appeared to be some confusion with the metabolic reactions involving ribosomes.

AfL: The topic of Golgi apparatus, location, structure and function could be reinforced via future teaching and learning.

Question 3(a)(ii)

(ii) State **one** function of the mitochondria in **Fig. 3.1**.

.....

.....**[1]**

It is very reassuring to see that the topic of mitochondria, however, is much more familiar. It was unfortunate that some candidates wrongly considered that energy is 'produced/generated' by such organelles. It was interesting to note that some candidates were very specific with reference to aerobic respiration for this organelle.

Question 3(b)

(b) Suggest why the single chloroplast appears as two distinct structures in the transmission electron micrograph shown in **Fig. 3.1**.

.....

.....**[1]**

The concept of microscope images / micrographs can be challenging. In this case, most candidates did not realise that a single chloroplast may be seen as two distinct structures due to the combination of the shape of the organelle and the sectioning achieved as part of the preparation for microscopy. As a result, relatively few candidates obtained the mark for this item. It is proposed that candidates are presented with a wider range of micrographs of cells and organelles to appreciate this concept more fully.

Question 3(c)

(c) The image in **Fig.3.1** shows some of the features of the chloroplast in a *Cymbomonas* cell.

Name **one** feature of a chloroplast and explain how this enables the chloroplast to function.

.....

.....

.....

.....**[2]**

Some candidates simply repeated standard features of chloroplasts based on the process of photosynthesis. This item involved the naming of a feature, followed by the explanation. The most common, correct feature was that of the large surface area provided to enhance the trapping of light. This was creditworthy although the details of thylakoids etc. were absent. The other most common feature was the presence of chlorophyll, sharing the same function.

Question 3(d)

(d) **Fig. 3.1** shows a number of bacteria in the vacuole of the cell.

Which organelle in a cell normally breaks down bacteria?

Tick (✓) **one** box.

Endoplasmic reticulum	☐
Lysosome	☐
Nucleus	☐
Ribosome	☐

[1]

As for the Golgi apparatus earlier in this question, the function of the lysosome was unclear. A number of candidates did correctly identify this organelle but others wrongly chose the endoplasmic reticulum.

Question 3(e)(i)

(e) Bacteria are prokaryotic.

Cymbomonas is eukaryotic.

(i) State **one difference** between prokaryotic and eukaryotic cells that is **visible** in **Fig. 3.1**.

.....

.....**[1]**

Question 3(e)(ii)

(ii) State **two similarities** between prokaryotic cells and eukaryotic cells that are **not visible** in **Fig. 3.1**.

1 .....

.....

2 .....

.....

[2]

Question 3(e)(iii)

(iii) State **two differences** between prokaryotic cells and eukaryotic cells that are **not visible** in **Fig. 3.1**.

1 .....

.....

2 .....

.....

[2]

The differences and similarities between prokaryotic and eukaryotic cells was a challenging topic for many candidates. The image provided in **Fig. 3.1** did clearly show prokaryotic cells (the bacteria) inside a eukaryotic cell (*Cymbomonas sp.*). However, candidates were unable to work through the series of items relating to this image. The image did not appear to provoke effective factual recall needed to succeed with the question. It should be noted that some candidates did do very well and obtained full marks.

Question 4(a)(i)

4 Polymers can be found all around us and are either synthetic or natural.

Natural polymers are found in plants and animals.

(a) (i) DNA is an example of a natural polymer. DNA is made up of four different monomers.

What is the name of the monomers that make up DNA?

Tick (✓) **one** box.

Alkenes	☐
Amino acids	☐
Glucose	☐
Nucleotides	☐

[1]

The concept of nucleotides as the monomers for DNA should be familiar to candidates. A number of candidates provided the correct response but others unfortunately chose alkenes or amino acids.

Question 4(a)(ii)

(ii) Each monomer in DNA has three parts – a sugar group, a phosphate group and one of four different bases.

Name **two** bases found in **DNA**.

Tick (✓) **two** boxes.

Adenine	☐
Adrenaline	☐
ATP	☐
Cellulose	☐
Thymine	☐
Thyroxine	☐
Uracil	☐

[2]

Having been encouraged to consider DNA and nucleotides, it was expected that candidates would successfully recall the two DNA bases as adenine and thymine. The strong distractor was uracil (restricted to RNA). Many candidates struggled to complete this item successfully whilst others were not overly challenged. No clear pattern of incorrect alternative responses was identified.

Question 4(a)(iii)

(iii) Natural polymers are also organic compounds.

There are different types of these compounds due to the nature of the carbon atom and the presence of other elements.

Some of the compounds are listed and described below.

Draw a line to link **each** type of compound to its correct description.

Type of compound	Description
Alkane	Organic compounds containing the C=O group.
Alkene	Organic compounds containing the COOH group.
Aldehyde	Organic compounds containing the OH group.
Carboxylic acid	Saturated hydrocarbons containing single C-C and C-H bonds.
Alcohol	Unsaturated hydrocarbons containing a C=C double bond.

[5]

This objective item, at first sight, seemed to be challenging but most candidates did very well and correctly identified all of the descriptions for the five compounds listed. The most common error was to confuse the description for alkane and alkene. Almost all candidates could recognise the distinguishing features of carboxylic acid and alcohol.

Question 4(b)

(b) Synthetic polymers are used to make plastics and are produced from oil.

Many polymers are produced from the polymerisation of alkenes.

Poly(propene) is produced from the polymerisation of the alkene propene.

Poly(propene) can be represented as shown in **Fig. 4.1**.

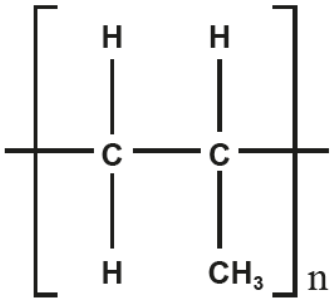


Fig. 4.1

Draw the structural formula of the monomer poly(propene) is formed from.

[2]

The key marking points were based on a double bond between carbons 1 and 2 and the correct ratio of carbon and hydrogen atoms. Many candidates obtained full marks although the structural formula was not produced in the ideal format. Some candidates successfully identified the formation of the double bond but did not recognise the correct carbon/hydrogen ratio.

Question 4(c)

(c) Scientists in the USA have found a method of producing a polymer called polyhydroxybutyrate (PHB). They can produce PHB by inserting genes from a bacterium into a type of grass called switchgrass.

The final stage in the production of PHB is controlled by an enzyme called PHB-synthase (PhaC).

Since PhaC is an enzyme, it is a type of protein.

Describe how PhaC is produced from the genetically-modified DNA of the switchgrass.

.....

.....

.....

.....**[5]**

The key feature of this item was an understanding of protein synthesis, including both transcription and translation. Although many candidates did very well and gave full descriptions, some appeared to be somewhat confused by the scenario.

Misconception: The misconception was to assume that details of gene manipulation were required to complete this item.

Question 5(a)

5 Manganese is one of the most abundant transition metals on Earth.

It is an essential trace element.

(a) Manganese compounds are added to animal feed.

Suggest **one** reason for the addition of manganese compounds to animal feed.

.....

.....**[1]**

The functions of manganese are listed in the specification. Any of the correct features, ranging from enzymes involved in the structural components to a role in liver function, were acceptable. However, many candidates referred to generalised features such as bone structure, without the required level of detail. This prevented them from obtaining the mark.

Question 5(b)(i)

(b) Table **5.1** shows the average concentration of manganese found in some tissues and organs of four different types of farm animals.

Tissue or organ	Average concentration of manganese (mg kg^{-1})			
	Cattle	Chickens	Ducks	Pigs
Kidney	1.4	2.4	2.5	1.6
Liver	3.5	4.1	10.4	4.2
Muscle	0.3	0.2	0.3	0.1

Table 5.1

(i) Which tissue or organ in **Table 5.1** has the highest concentration of manganese?
Put a (ring) around the correct answer.

Kidney **Liver** **Muscle**

[1]

The liver was clearly the organ with the highest concentration of manganese. Almost all candidates correctly identified this feature of **Table 5.1**.

Question 5(b)(ii)

(ii) Which animal in **Table 5.1** has the lowest concentration of manganese?
Put a (ring) around the correct answer.

Cattle **Chickens** **Ducks** **Pigs**

[1]

Table 5.1 indicated that either cattle or pigs showed the lowest concentration of manganese. The optional answers related to the way in which the data are shown in the table. Almost all candidates obtained the mark.

Question 5(c)

(c) The most common oxidation states of manganese are +2, +3, +4, +6 and +7.
Only +2, +3 and +4 have been found in mammalian tissues.

Complete **Table 5.2** by filling in the oxidation states of the manganese compounds listed.

One has been done for you.

Manganese compound	Oxidation state
$MnCl_2$	+2
Mn_2O_3	
MnO_2	

Table 5.2

[2]

The expected answers were +3 followed by +4. A number of candidates gave the correct responses but an almost equal number appeared to be confused by this item.

AfL: The topic of 'oxidation states' could be reinforced for some candidates.

Question 5(d)

(d) What happens during the oxidation of an atom?

Tick (✓) **one** box.

Electrons are gained	☐
Electrons are lost	☐
Neutrons are gained	☐
Neutrons are lost	☐
Protons are gained	☐
Protons are lost	☐

[1]

This is a very familiar topic for candidates and the vast majority realised that electrons are lost during the oxidation of an atom. No clear pattern of alternative, incorrect responses could be identified.

Question 5(e)

(e) The disease bovine spongiform encephalopathy (BSE) or 'mad cow disease' usually affects cows.

The disease mostly affects the brain, where an abnormal form of a protein called prion accumulates. Normal and abnormal prion proteins are thought to contain a metal.

Scientists have studied the concentration of manganese in prion proteins in different parts of the nervous systems and blood of cows with BSE and those without the disease.

The results from the study are shown in **Table 5.3**.

Region of body	Condition of cow	Concentration of manganese (ppb)
Brain cortex	Without BSE	326
	BSE	34
Brain stem	Without BSE	191
	BSE	415
Spinal cord	Without BSE	266
	BSE	365
Blood	Without BSE	49
	BSE	83

Table 5.3

Describe the trend and the conclusions that can be drawn from the data in **Table 5.3**.

.....

.....

.....

.....**[6]**

Many candidates did very well in terms of the data description. They are clearly familiar with interpreting data presented in this type of table and repeating the data in text form. It was good to see that, on a number of occasions, candidates referred to actual or calculated values to reinforce their description. However, most candidates were restricted to 1 or 2 marks out of 6 since they did not consider the data in relation to a clear conclusion. Most candidates did not include one conclusion within their response.

Question 5(f)

(f) **Table 5.4** shows the results of a study in the USA on the effects of manganese on a form of arthritis called rheumatoid arthritis.

The scientists estimated the risk of developing the condition from estimates of manganese intake in people's diet.

Less than 2.09	2.09 – 3.00	Greater than 3.00
1.00	0.93	1.07

Table 5.4

What conclusion can be drawn from the results in **Table 5.4**?

.....

.....

.....**[1]**

Although the data shown in **Table 5.4** are not very revealing, many candidates did very well with this item and did their best to relate the ranges to the risk of developing this condition. Some candidates provided general correlations without considering the details provided in the table.

Question 5(g)

(g) Manganese is just one of many metal ions with biological functions.

Three of the other metal ions are: **iron**, **nickel** and **calcium**.

Draw a line to link each function to the correct ion.

Function	Ion
Carriage of oxygen in haemoglobin and myoglobin.	**Calcium**
Component of the enzyme, hydrolase.	**Iron**
Needed for the formation of bone matrix.	**Nickel**

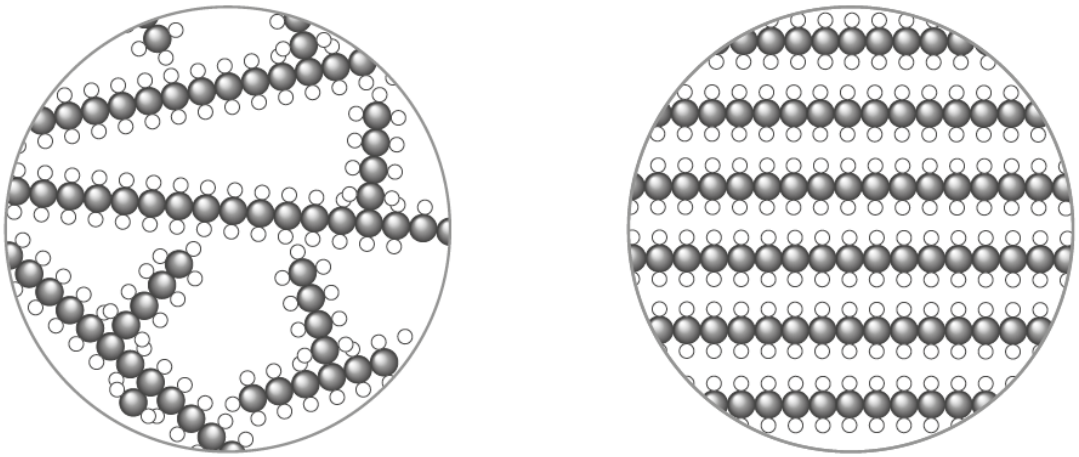
[2]

Almost all candidates obtained full marks for this item. It is clear that they were familiar with the roles of iron, nickel and calcium. The line-linking approach of this objective item may well have enabled greater access to this topic, almost via a process of elimination.

Question 6(a)

6 Alice is investigating the features of poly(ethene).

Fig. 6.1 shows two forms of the molecular structure of poly(ethene).



Form 1 **Form 2**

Fig. 6.1

(a) Identify **two** differences between the molecular structures of poly(ethene) **Form 1** and **Form 2** shown in **Fig. 6.1**.

1.....

2.....

[2]

Most candidates were able to give a realistic account of the difference between the two forms shown in **Fig. 6.1**. Unfortunately, some candidates forgot to name the form they were referring to (Form 1 or Form 2). This prevented them from obtaining the marks. It should be noted that this is the standard rubric for this type of item. Candidates should remember to identify the 'subject' for the named differences.

Question 6(b)

Alice takes samples of each of the two forms of poly(ethene) and tests them to measure their tensile strength, hardness and melting point.

Table 6.1 shows the results of the tests.

Form of poly(ethene)	Tensile strength (MPa)	Hardness	Melting point (°C)
1	9	48	112
2	32	68	131

Table 6.1

(b) Suggest **three** conclusions that can be made from the results in **Table 6.1**.

.....

.....

.....

.....

.....**[3]**

This was a successful item for the vast majority of candidates. They were able to identify the three conclusions shown in the table ie. Form 2 has the greatest tensile strength, greatest hardness and highest melting point.

Question 6(c)

(c) Explain how the differences in structure between **Form 1** and **Form 2** produce the different properties shown in **Table 6.1**.

.....

.....

.....

.....

.....**[3]**

It was the explanation that proved to be most challenging. The closeness of the chains and the strength of intermolecular forces were not considered by most candidates. There was a tendency to repeat the response already written for 6(b) without an explanation.

Question 7(a)(i)

7 A rechargeable battery contains twelve cells connected in series with a resistor **X**.

Each cell has an internal resistance r_c, of 0.5 Ω and an electromotive force (e.m.f.) of 2.3 V.

(a) (i) Calculate the e.m.f. of the rechargeable battery.

e.m.f. = ... V

[1]

Question 7(a)(ii)

(ii) Calculate the internal resistance r_B of the rechargeable battery.

internal resistance r_B = ... Ω

[1]

Question 7(b)(i)

(b) The rechargeable battery is connected to a direct current supply with an e.m.f of 100 V.

The e.m.f. of the rechargeable battery opposes the e.m.f of the power supply.

(i) Calculate the **net** e.m.f. of the circuit.

net e.m.f. = ... V

[1]

Question 7(b)(ii)

(ii) The current in the circuit is 2.6 A.

Calculate the resistance of resistor X.

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

resistance of **X** = ... Ω

[5]

Many candidates did very well with this question. They were able to apply the calculations correctly and link the responses between different items. An 'error carried forward' (ecf) was used when marking this question. This ensured that candidates who had made a slight error earlier were not unfairly penalised in later parts.

AfL: In general, candidates may benefit from a more detailed consideration of this topic. Although some formulae are provided via the data sheet for this paper, candidates continue to struggle with some of the more challenging concepts.

The small print

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