Oxford Cambridge and RSA

Level 3 Alternative Academic Qualification Cambridge Advanced Nationals in Applied Science

H051/H151 Unit F180: Fundamentals of science

Sample Assessment Material (SAM)

Time allowed: 1 hour 30 minutes
XXX/XXXX

You may use:
- scientific calculator
- ruler

You should have:
- the Data, Formulae and Relationship Booklet

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) ______________________

Last name ______________________

Date of birth D D M M Y Y Y Y

INSTRUCTIONS
- Use black ink.
- Write your answer to each question in the space provided. You can use extra paper if you need to, but you must clearly show your candidate number, the centre number and the question numbers.
- In the live exam there might be lined pages at the end of the question paper for you to use if you need extra space. Remember, you must clearly show the question numbers.
- Answer **all** the questions.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **20** pages.

ADVICE
- Read each question carefully before you start your answer.

Answer **all** the questions.

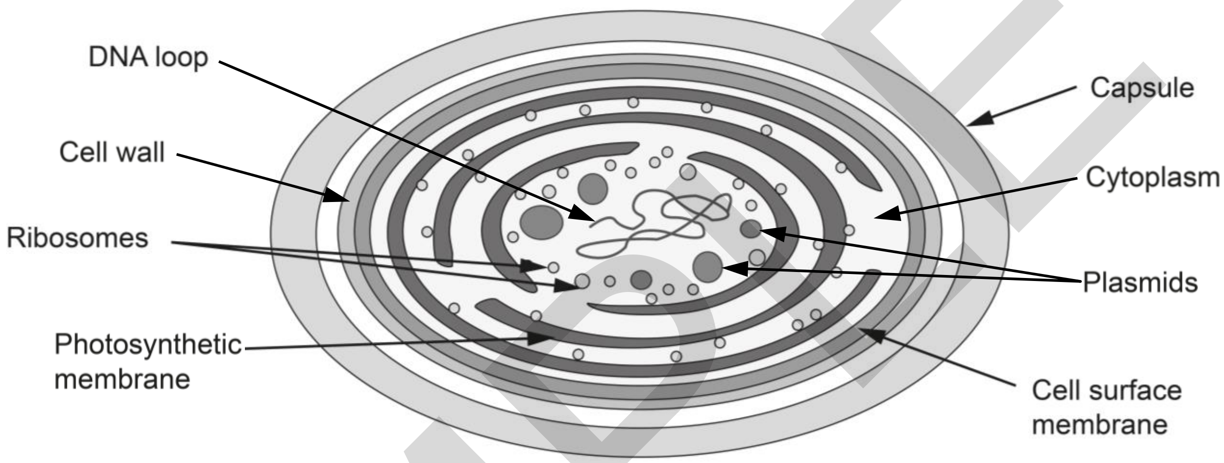
Section A (Biology) – 20 marks

1 A student is studying endosymbiosis in cells.

Endosymbiosis is seen when one organism lives inside of another and both organisms benefit from this relationship.

(a) Chloroplasts are thought to have evolved from a type of bacteria called cyanobacteria.

The diagram shows the structures of a cyanobacteria cell.



(i) Which **three** structures found in cyanobacteria are also found in plant cells?

Tick (✓) **three** boxes.

Capsule ☐

Cell surface membrane ☐

Cell wall ☐

Cytoplasm ☐

DNA loop ☐

Plasmids ☐

[3]

(ii) Some structures seen in the cyanobacteria cell in the diagram share the same function with components found in a chloroplast.

Complete the table to match the function of structures seen in the cyanobacteria cell to the component found in a chloroplast.

Component found in a chloroplast	Structure seen in the cyanobacteria cell
Outer membrane	....
Stroma	....
Thylakoids	....

[3]

(b) A scanning electron microscope (SEM) can be used to view an individual cyanobacteria cell.

State **one** advantage and **one** disadvantage of using an SEM compared to a transmission electron microscope (TEM).

Advantage ....

....

Disadvantage ....

....

[2]

2 A group of scientists are investigating sperm cells in humans.

Normal-functioning sperm cells contain many mitochondria, packed into the middle piece.

(a) The aerobic phase of cellular respiration takes place inside each mitochondrion.

State **two** structural components of the mitochondria involved in the aerobic phase of respiration.

1 ....

2 ....
[2]

(b) The scientists estimate that normal sperm cells contain 60 mitochondria in the middle piece.

The table shows relatively lower numbers of mitochondria found in a sample of abnormal sperm cells.

41	32	42	49	27
46	35	44	48	37

(i) Calculate the mean number of mitochondria found in the abnormal sperm cells.

Mean number of mitochondria = ... **[1]**

(ii) Calculate the percentage difference between the mean number of mitochondria found in abnormal sperm cells and the estimated number of mitochondria in normal sperm cells.

Give your answer to **2** decimal places.

Percentage difference = ... % **[1]**

(iii) Explain **one** impact of low numbers of mitochondria on the activity of abnormal sperm cells.

....

....

....

.... **[2]**

3 Pea protein is extracted from yellow peas.

(a) Pea protein provides a wide range of amino acids in the human diet.

(i) The amino acids can form dipeptides.

Describe the process of dipeptide formation.

....

....

....

.... **[2]**

(ii) Pea proteins have a secondary level of organisation.

What is the secondary level of organisation in proteins?

Tick (✓) **one** box.

Folding of a single polypeptide chain to form an α-helix or β-pleated sheet ☐

More than one polypeptide chain folded to form a 3D shape ☐

The sequence of amino acids in a polypeptide chain ☐

3D folding of a single polypeptide chain due to side-chain interactions ☐

[1]

(b) Pea plants are grown as an agricultural crop.

Pea plants are often vulnerable to diseases.

(i) The distribution of diseased pea plants in a field is determined using a random sampling technique.

State **one** benefit and **one** limitation of using random sampling.

Benefit ....

....

Limitation ....

....

[2]

(ii) State **one** climatic abiotic factor affecting the distribution of pea plants in an agricultural field.

.... **[1]**

Section B (Chemistry) – 20 marks

4 Sulfur (atomic number 16) is an element in the Earth's crust. It is released into the atmosphere when a volcano erupts.

(a) The two most abundant isotopes of sulfur are sulfur-32 and sulfur-34.

(i) Explain why sulfur-32 and sulfur-34 are described as isotopes of sulfur.

....

.... **[1]**

(ii) A scientist analyses a sample of sulfur from a volcano and finds that there are three isotopes present. They determine the relative masses and percentage (%) abundances of these isotopes:

Isotope	Symbol	Abundance (%)
Sulfur-32	^{32}S	95.02
Sulfur-33	^{33}S	0.77
Sulfur-34	^{34}S	4.21

Calculate the relative atomic mass of the sample of sulfur.

Give your answer to **two** decimal places.

Relative atomic mass = ... **[2]**

(b) Complete the electron configuration of sulfur, using sub-shell notation.

Electronic configuration of sulfur = $1s^2$ .... **[1]**

5 Calcium carbonate, $CaCO_3$, occurs naturally in the Earth's crust as limestone and chalk.

(a) Calcium carbonate decomposes when heated strongly to form calcium oxide and carbon dioxide.

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

(i) Calculate the number of moles of CO_2 produced when 2000 g of $CaCO_3$ decomposes.

Give your answer to an appropriate number of significant figures.

Molar mass of $CaCO_3$ = 100.1 g mol^{-1}

Number of moles of CO_2 = ... **[2]**

(ii) Calculate the volume of CO_2 formed at room temperature and pressure (RTP).

Molar gas volume = 24.0 $dm^3 mol^{-1}$ at RTP

Volume of CO_2 = ... dm^3 **[1]**

(b) Calcium carbonate reacts with nitric acid.

Explain the type of reaction between calcium carbonate and nitric acid.

....

.... **[1]**

6 Properties of substances are determined by the type of structure and bonding present.

(a)

(i) What is a covalent bond?

....

.... **[1]**

(ii) Na_2CO_3 contains the carbonate ion, CO_3^{2-}.

Draw a dot and cross diagram for the carbonate ion.

[2]

(b) A substance **X** has the following properties:

- a high melting point
- does not conduct electricity when solid
- does not conduct electricity when molten
- does not dissolve in water.

Which type of structure is substance **X**?

Tick (✓) **one** box.

Giant ionic ☐

Giant covalent ☐

Giant metallic ☐

Simple molecular ☐

[1]

(c) Aluminium nitrate is an ionic compound.

What is the correct formula of aluminium nitrate?

Tick (✓) **one** box.

$AlNO_3$ ☐

Al_3NO_3 ☐

$(Al_2NO_3)_3$ ☐

$Al(NO_3)_3$ ☐

[1]

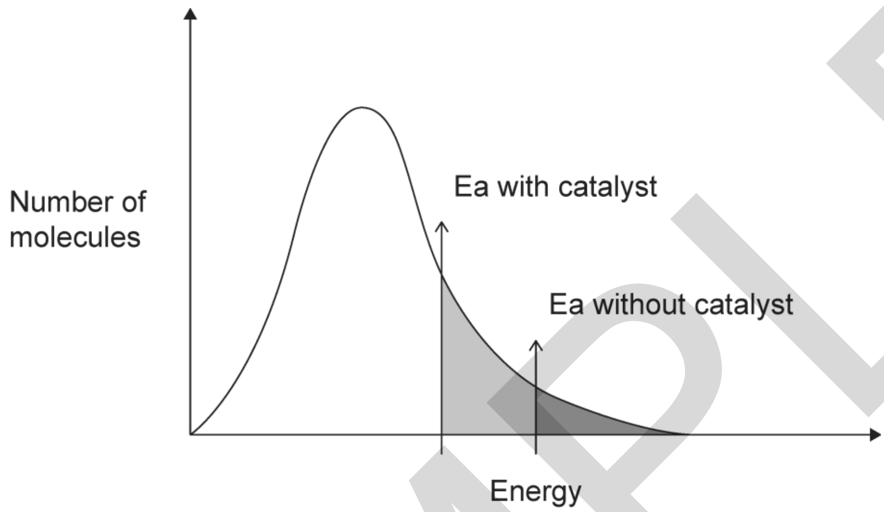
7 Catalysts are important in the chemical industry because they speed up chemical reactions and remain unchanged at the end of the reaction.

(a) Explain what is meant by the activation energy (E_a) of a chemical reaction.

....

.... **[1]**

(b) Use the Boltzmann distribution curve to explain the effect of a catalyst on a reaction.



....

....

....

....

.... **[2]**

8 Butane and ethanol are both useful fuels.

(a) Write the balanced equation for the complete combustion of ethanol.

.... **[2]**

(b) Explain **one** advantage of using ethanol as a fuel rather than butane.

....

.... **[1]**

(c) Butanal is a derivative of butane.

Draw the displayed formula of butanal.

[1]

Section C (Physics) – 20 marks

9 Some cranes use electricity to raise, lower and move loads.

(a) What is potential difference?

....

.... **[1]**

(b) An electric crane lifts a 100 kg mass through a vertical height of 15 m in a time of 1.5 minutes.

(i) Calculate the work done to lift the mass.

Work done = ... J **[2]**

(ii) The crane is 37% efficient. The work done to lift the mass is approximately 15 000 J.

Calculate the input power to the crane.

Input power = ...W **[3]**

(c) The potential difference across the crane's motor is 600 V.

Calculate the current drawn by the crane.

Current = ... A **[2]**

10 A patient has visited their doctor to discuss bone pain that they are experiencing. They are referred for an X-ray to look for any problems in the bones.

(a) Explain how X-ray photons are produced in an X-ray tube.

You may draw a labelled diagram.

....

....

....

....

....

.... **[3]**

(b) The nuclear medicine department of a hospital uses radionuclides to treat bone cancer.

List **three** types of nuclear radiation in order of **decreasing** mass that can be emitted from radionuclides.

Heaviest 1 ....

2 ....

Lightest 3 ....

[1]

(c) Explain how nuclear radiation can damage DNA indirectly.

....

....

....

....

....

....

....

.... **[4]**

(d) Radionuclides are used in radiotherapy to treat bone cancers.

The radionuclide is:

- injected into the patient
- absorbed by the bones
- kills bone cells by ionising them.

The table shows the properties of four radionuclides that are available:

Radionuclide	Emission	Half-life
A	gamma	2.6 years
B	gamma	6 hours
C	beta	12.3 years
D	beta	50 days

Explain why Radionuclide **D** is chosen for this radiotherapy.

....

....

....

....

....

....

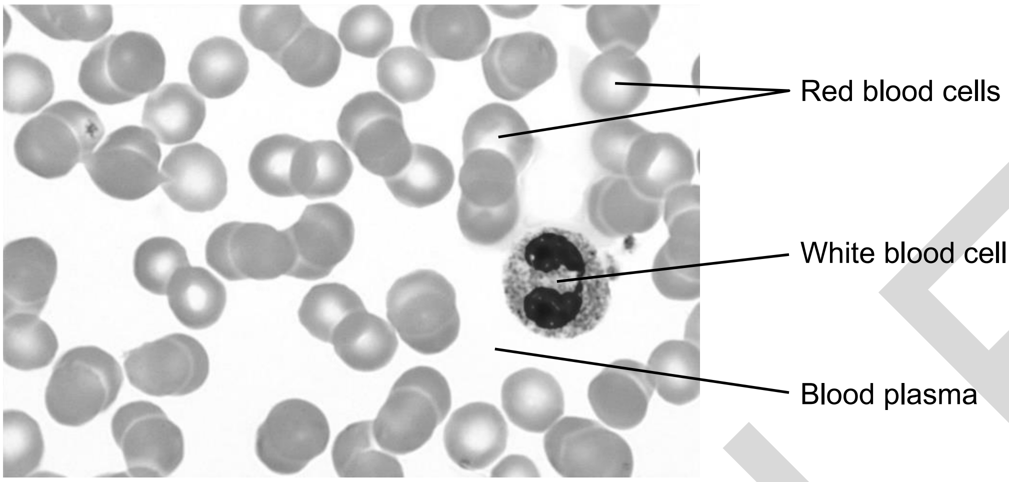
....

.... **[4]**

Section D (Practicals) – 10 marks

11 A laboratory technician prepares a temporary, stained microscope slide of a blood smear.

The photomicrograph shows a white blood cell in the blood smear.



(a)
(i) Identify **two** differences between the white and red blood cells shown in the photomicrograph.

....

....

....

.... **[2]**

(ii) The actual vertical length of the white blood cell in the photomicrograph is 22 μm.

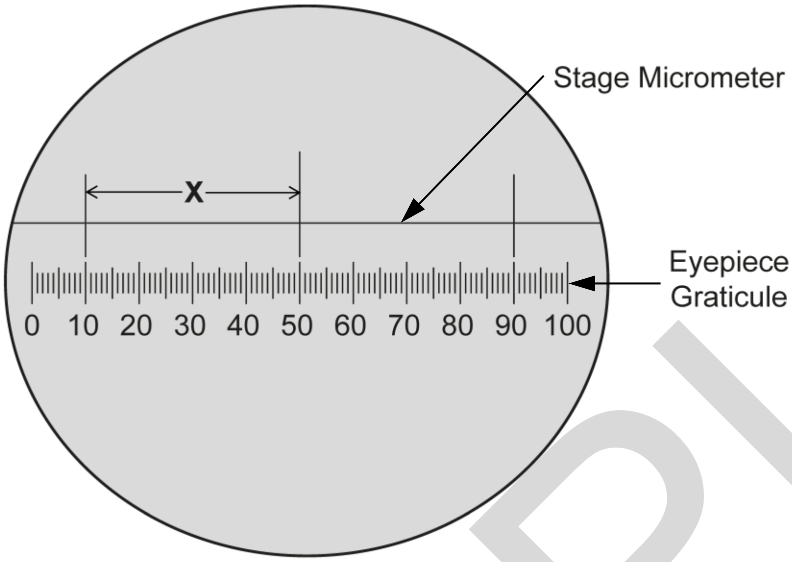
Calculate the magnification of the image.

Magnification = × .... **[3]**

(b) The technician uses an eyepiece graticule to measure the dimensions of blood cells.

- The eyepiece graticule is calibrated using a stage micrometer.
- The stage micrometer is viewed alongside the eyepiece graticule scale line.
- The eyepiece graticule scale line contains 100 divisions.

The drawing shows the two scale lines alongside each other.



(i) The distance **X** on the stage micrometer is **0.1 mm**.

Calculate the length of an eyepiece graticule division, using the drawing.

Length = ... μm **[3]**

(ii) The technician uses the calibrated eyepiece graticule to estimate the width of five different white blood cells found in the stained blood smear.

The table shows the measurements recorded.

Replicate	**Width of white blood cell (μm)**
1	17.0
2	19.0
3	22.0
4	20.5
5	16.5

The width of the white blood cell shown in the photomicrograph is 18.0 μm.

Explain the extent of the variation of measurements shown in the table.

....

....

.... **[1]**

(iii) Explain **one** improvement to be made by the technician to obtain a more accurate estimate for the width of white blood cells.

....

....

.... **[1]**

END OF QUESTION PAPER

THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK

THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK

THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK

This is sample assessment material for our specification. It is to help show how the live assessment materials will look. During the lifetime of the qualification you might see small adjustments to the assessment materials. This is part of continuous improvement, designed to help you and your students. We recommend you look at the most recent set of past papers where available.

OCR
Oxford Cambridge and RSA

Level 3 Alternative Academic Qualification Cambridge Advanced Nationals in Applied Science

Unit F180: Fundamentals of science

Sample Assessment Material (SAM)

Mark Scheme

This document has **13** pages.

MARKING INSTRUCTIONS

Crossed-out answers

If a student has crossed out an answer and written a clear alternative, do **not** mark the crossed-out answer.

If a student has crossed out an answer and **not** written a clear alternative, give the student the benefit of the doubt and mark the crossed-out answer if it's readable.

Multiple choice question answers

When a multiple choice question has only one correct answer and a student has written two or more answers (even if one of these answers is correct), you should **not** award a mark.

When a student writes more than one answer

1. Questions that ask for a set number (including 1) of short answers or points

If a question asks for a set number of short answers or points (e.g. **two** reasons for something), mark only the **first set number** of answers/points.

First mark the answers/points against any printed numbers on the answer lines, marking the **first** answer/point written against each printed number. **Then**, if students have not followed the printed numbers, mark the answers/points from left to right on each line and **then** line by line until the set number of answers/points have been marked. Do **not** mark the remaining answers/points.

2. Questions that ask for a single developed answer

If a student has written two or more answers to a question that only requires a single (developed) answer, and has **not** crossed out unintended answers, mark only the first answer.

3. Contradictory answers in points-based questions

When a student has written contradictory answers, do **not** award any marks, even if one of the answers is correct.

Levels of Response marking

1. To determine the level start at the highest level and work down until you reach the level that best describes the answer

2. To determine the mark within the level, consider the following:

Quality of the answer	Award mark
Consistently meets the criteria for this level	At the top of the level (6 and 9 mark questions)
Meets the criteria but with some inconsistency	At the middle of the level (9 mark questions)
On the borderline of this level and the one below	At the bottom of the level (6 and 9 mark questions)

MARK SCHEME

Section A (Biology) - 20 marks

1 (a) (i)	
Max mark	3 (PO1)
Answer	<table><tr><td>Capsule</td><td></td><td></td></tr><tr><td>Cell surface membrane</td><td>✓</td><td>(1)</td></tr><tr><td>Cell wall</td><td>✓</td><td>(1)</td></tr><tr><td>Cytoplasm</td><td>✓</td><td>(1)</td></tr><tr><td>DNA loop</td><td></td><td></td></tr><tr><td>Plasmids</td><td></td><td></td></tr></table>
Guidance	If a candidate ticks **more than three** boxes, delete one mark for each additional tick.

1 (a) (ii)	
Max mark	3 (PO2)
Answer	<table><tr><th>Component of chloroplast</th><th>Structure in cyanobacteria cell</th><th></th></tr><tr><td>Outer membrane</td><td>Cell (surface) membrane</td><td>(1)</td></tr><tr><td>Stroma</td><td>Cytoplasm</td><td>(1)</td></tr><tr><td>Thylakoids</td><td>Photosynthetic membranes</td><td>(1)</td></tr></table>
Guidance	

1 (b)	
Max mark	2 (PO1)
Answer	Any **one** from **(advantage):** • SEM shows details of (cyanobacteria) cell surface (1) • Does not require ultra-thin specimens (1) • Less preparation time (1) Any **one** from **(disadvantage):** • SEM has a less powerful resolution/magnification (1) • SEM cannot show internal details of (cyanobacteria) cell contents (1)
Guidance	Allow alternative correct answers. Allow vice versa responses for TEM if clearly qualified.

2 (a)	
Max mark	2 (PO1)
Answer	Any **two** from: • Cristae (1) • Matrix (1) • (ATP synthase) particles on cristae surface (1)
Guidance	Allow alternative wording for ‘particles’.

2 (b) (i)	
Max mark	1 (PO2)
Answer	(41 + 32 + 42 + 49 + 27 + 46 + 35 + 44 + 48 + 37)/10 = <u>40 (to nearest whole number)</u> (1)
Guidance	Do **not** allow 40.1

2 (b) (ii)	
Max mark	1 (PO2)
Answer	(% difference of mitochondria in sperm cells = 40/60 × 100) = <u>66.67</u> (1)
Guidance	Allow **ECF** using answer to **2(b)(i)** (÷ 60 × 100)

2 (b) (iii)	
Max mark	2 (PO1)
Answer	**Impact on sperm cell activity** Any **one** from: • Slower/no swimming OR tail/flagellum moves more slowly (1) • Acrosome cannot discharge contents at fertilisation (1) • Reduced chance of fertilising the egg/ovum (1) **Explanation** Any **one** from: • Less energy released / ATP provided (1) • Reduction in energy coupling processes (1) • Overall metabolic rate of sperm cell is lowered (1)
Guidance	Allow alternative correct answers.

3 (a) (i)	
Max mark	2 (PO1)
Answer	Condensation reaction / H_2O released (1) (Adjacent) amino and carboxyl groups involved (1)
Guidance	Allow a correct, labelled/annotated diagram. Ignore ‘dipeptide bond’ for the 2nd marking point.

<table>
<tr><th>3 (a) (ii)</th><th></th></tr>
<tr><td>Max mark</td><td>1
(PO1)</td></tr>
<tr><td>Answer</td><td>
<table>
<tr><td>Folding of a single polypeptide chain to form an α helix or β pleated sheet.</td><td>✓</td><td>(1)</td></tr>
<tr><td>More than one polypeptide chain folded to form a three-dimensional shape.</td><td></td><td></td></tr>
<tr><td>The sequence of amino acids within a polypeptide chain.</td><td></td><td></td></tr>
<tr><td>Three-dimensional folding of a single polypeptide chain due to side chain interactions.</td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Guidance</td><td>If a candidate ticks more than one box, award zero for the item.</td></tr>
</table>

3 (b) (i)	
Max mark	2 (PO1)
Answer	**Benefit** Any **one** from: • Removes/reduces bias (1) • (Relatively) quick to complete (1) • Allows sampling of a subset of the (plant) population (1) **Limitation** Any **one** from: • Not representative (of % cover of diseased pea plants) (1) • Less effective if distribution pattern is uneven/patchy (1) • Difficult to estimate the number of sample areas/quadrats needed (1) • Based on the assumption that the samples are (truly) random (1) • May require a grid and use of randomised number generator (1)
Guidance	Allow alternative wording. Allow correct alternative answers.

3 (b) (ii)	
Max mark	1 (PO1)
Answer	Any **one** from: • Light intensity (1) • Wind speed/direction (1) • % humidity of air (1) • Air temperature (1)
Guidance	Allow alternative correct answers. Do not allow biotic/living factors.

Section B (Chemistry) - 20 marks

4 (a) (i)	
Max mark	1 (PO1)
Answer	Both have 16 protons but S-34 has two more neutrons than S-32 (1)
Guidance	Use of sulfur-32 and sulfur-34 data is required for mark.

4 (a) (ii)	
Max mark	2 (PO2)
Answer	$Ar = \frac{(32 \times 95.02) + (33 \times 0.77) + (34 \times 4.21)}{100}$ (1) = 32.09 (to 2 decimal places) (1)
Guidance	If answer = 32.09 award 2 marks

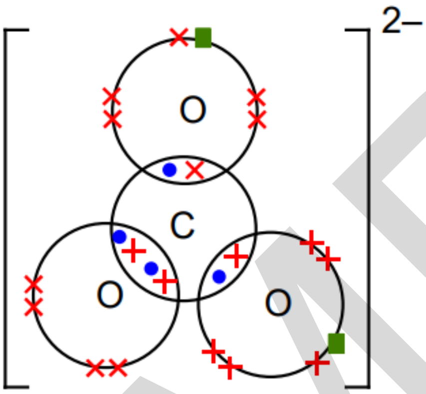
4 (b)	
Max mark	1 (PO2)
Answer	$(1s^2)2s^22p^63s^23p^4$ (1)
Guidance	

5 (a) (i)	
Max mark	2 (PO2)
Answer	Moles of $CaCO_3$ = 2000/100.1 = 19.98 (1) Moles of CO_2 = 19.98 (to 4 significant figures) (1)
Guidance	If answer = 19.98 award 2 marks Do not allow values quoted that are greater than 4 significant figures

5 (a) (ii)	
Max mark	1 (PO2)
Answer	Volume of CO_2 = 19.98 × 24 = 479.52 (dm^3) (1)
Guidance	Allow 480 (dm^3) for 1 mark Allow ECF from 2(a)(i)

5 (b)	
Max mark	1 (PO1)
Answer	Neutralisation because an acid is reacting with a base to form a salt (1)
Guidance	Allow Neutralisation because the H^+ ions and OH^- ions are reacting to form water.

6 (a) (i)	
Max mark	1 (PO1)
Answer	A covalent bond is the strong electrostatic attraction between a shared pair of electrons and the nuclei of the bonded atoms (1)
Guidance	Do not allow electrons are shared.

6 (a) (ii)	
Max mark	2 (PO2)
Answer	First mark for bonding around central C atom (1) Second mark for non-bonded electrons around 3 O atoms (1)
Guidance	 **Global rules** • C and O electrons must be shown differently, e.g. for • C and × for O

6 (b)	
Max mark	1 (PO1)
Answer	Giant covalent (1)
Guidance	

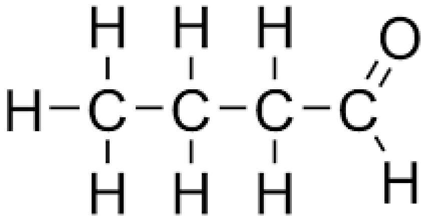
6 (c)	
Max mark	1 (PO2)
Answer	$Al(NO_3)_3$ (1)
Guidance	

7 (a)	
Max mark	1 (PO1)
Answer	Activation energy is the <u>minimum</u> amount of energy required for a reaction to occur. (1)
Guidance	

7 (b)	
Max mark	2 (PO1)
Answer	• The graph shows a greater area under the curve when a catalyst is used (1) • This means that more molecules have energy greater than the activation energy (1)
Guidance	Do not allow line with catalyst is higher than line without catalyst

8 (a)	
Max mark	2 (PO2)
Answer	$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ (2)
Guidance	Mark 1: correct left hand side Mark 2: correct right hand side

8 (b)	
Max mark	1 (PO1)
Answer	Any **one** from: • Ethanol is a renewable source so won't run out like butane (1) • Ethanol burns more cleanly so produces less CO_2 compared to butane (1) • Ethanol will produce less CO and particulates than butane (1)
Guidance	Allow alternative correct answers.

8 (c)	
Max mark	1 (PO1)
Answer	 (1)
Guidance	Do not allow structural formulae: $CH_3CH_2CH_2CHO$

Section C (Physics) - 20 marks

9 (a)	
Max mark	1 (PO1)
Answer	Work done per unit charge (1)
Guidance	Allow alternative correct answers

9 (b) (i)	
Max mark	2 (PO2)
Answer	∆GPE = 100 x 9.81 x 15 (1) 14 715 (J) (1)
Guidance	If answer = 14 715 (J) award 2 marks Answer must be to 3 or more sig. figs. Do not allow 15 000 (J)

9 (b) (ii)	
Max mark	3 (PO2)
Answer	Work done on crane (total energy transferred) 14 715 ÷ 0.37 = 39 770 (J) (1) 39 770 ÷ 90 (1) = 441.891 (recurring) (W) (1)
Guidance	If answer = 441.891 (W) award 3 marks

9 (c)	
Max mark	2 (PO2)
Answer	I = 441.891 ÷ 600 (1) = 0.736 (A) (1)
Guidance	If answer = 0.736 (W) or 0.736486 (W) award 2 marks

10 (a)	
Max mark	3 (PO1)
Answer	• High voltage (supply) connected between cathode and anode (1) • (Accelerated) electrons hit the target/metal/anode (1) • KE is transformed into X-ray (photons) (1)
Guidance	

10 (b)	
Max mark	1 (PO1)
Answer	(Heaviest) Alpha Beta (Lightest) Gamma (1)
Guidance	

10 (c)	
Max mark	4 (PO1)
Answer	• Gamma radiation is able to create free radicals from water (1) • because the radiation is high frequency and therefore high energy (1) • The free radicals from the water ionise the DNA (1) • because they have an unpaired electron which means they are highly reactive (1)
Guidance	Allow gamma rays

10 (d)	
Max mark	4 (PO2)
Answer	Any **four** from: • D is a beta emitter so is more ionising than radionuclides A and B (1) • D is a beta emitter so will be energetic enough to kill/ionise/destroy the tumour cells (1) • D has a shorter half-life than C so will be active in the patient for less time / will expose the patient to less ionising radiation (1) • Gamma rays could damage healthy tissue due to its penetrating power (1) • Half-life of radionuclide A and C is too long, as they would expose the patient to excessive ionising radiation (1)
Guidance	

Section D (Practicals) - 10 marks

11 (a) (i)	
Max mark	2 (PO2)
Answer	Any **two** from: • WBCs are larger than RBCs (1) • RBCs have a great density than WBCs (1) • WBC/monocyte/leukocyte has a large/prominent nucleus **OR** RBCs lack a nucleus (1) • Nucleus in the WBC contains a nucleolus (1) • WBCs appear to have a thinner/lighter centre **OR** are folded/crenated/disc-like (1) • Nucleus in the white blood cell is heavily stained (1) • RBCs are not heavily stained (1)
Guidance	Allow alternative wording. Allow alternative correct answers.

11 (a) (ii)	
Max mark	3 (PO2)
Answer	observed size = 15 mm (Allow +/- 2 mm) (1) magnification = $(15 \times 10^3) \div 22$ (1) = 681.8 × (1)
Guidance	If answer = 681.8 / 682× give **3 marks**. Allow range 590.9 to 772.7× If not, give **1 mark (max)** for correct use of the equation.

11 (b) (i)	
Max mark	3 (PO2)
Answer	length of **X** = 0.1 mm = 100 μm (1) 40 eyepiece graticule divisions = 100 μm (1) 1 eyepiece graticule division = 100 ÷ 40 = 2.5 μm (1)
Guidance	If answer = 2.5 μm give **2 marks**. If not, give **1 mark (max.)** for any **one** of the calculation steps

11 (b) (ii)	
Max mark	1 (PO2)
	Any **one** from: • Not perfectly circular, so random/measurement error in measuring width of white blood cells (1) • White blood cells may be at different stages of development/growth (1)
Guidance	Allow alternative wording. Allow correct alternative answers.

11 (b) (iii)	
Max mark	1 (PO2)
Answer	Any **one** from: • Use a higher resolution graticule to get more precise data (1) • Find mean width of each blood cell by recording multiple measurements (1) • Use a larger number of replicates to remove outliers (1)
Guidance	Allow alternative wording. Allow correct alternative answers.

Oxford Cambridge and RSA

Level 3 Alternative Academic Qualification Cambridge Advanced Nationals in Applied Science

H051/H151 Unit F180: Fundamentals of science

Sample Assessment Material (SAM)

Data, Formulae and Relationships Booklet

The Periodic Table of the Elements

Key
atomic number
Symbol
name
relative atomic mass

(1) 1	(2) 2	3	4	5	6	7	8	9	10	11	12	(3) 13	(4) 14	(5) 15	(6) 16	(7) 17	(0) 18
1 **H** hydrogen 1.0																	2 **He** helium 4.0
3 **Li** lithium 6.9	4 **Be** beryllium 9.0											5 **B** boron 10.8	6 **C** carbon 12.0	7 **N** nitrogen 14.0	8 **O** oxygen 16.0	9 **F** fluorine 19.0	10 **Ne** neon 20.2
11 **Na** sodium 23.0	12 **Mg** magnesium 24.3											13 **Al** aluminium 27.0	14 **Si** silicon 28.1	15 **P** phosphorus 31.0	16 **S** sulfur 32.1	17 **Cl** chlorine 35.5	18 **Ar** argon 39.9
19 **K** potassium 39.1	20 **Ca** calcium 40.1	21 **Sc** scandium 45.0	22 **Ti** titanium 47.9	23 **V** vanadium 50.9	24 **Cr** chromium 52.0	25 **Mn** manganese 54.9	26 **Fe** iron 55.8	27 **Co** cobalt 58.9	28 **Ni** nickel 58.7	29 **Cu** copper 63.5	30 **Zn** zinc 65.4	31 **Ga** gallium 69.7	32 **Ge** germanium 72.6	33 **As** arsenic 74.9	34 **Se** selenium 79.0	35 **Br** bromine 79.9	36 **Kr** krypton 83.8
37 **Rb** rubidium 85.5	38 **Sr** strontium 87.6	39 **Y** yttrium 88.9	40 **Zr** zirconium 91.2	41 **Nb** niobium 92.9	42 **Mo** molybdenum 95.9	43 **Tc** technetium	44 **Ru** ruthenium 101.1	45 **Rh** rhodium 102.9	46 **Pd** palladium 106.4	47 **Ag** silver 107.9	48 **Cd** cadmium 112.4	49 **In** indium 114.8	50 **Sn** tin 118.7	51 **Sb** antimony 121.8	52 **Te** tellurium 127.6	53 **I** iodine 126.9	54 **Xe** xenon 131.3
55 **Cs** caesium 132.9	56 **Ba** barium 137.3	57–71 lanthanoids	72 **Hf** hafnium 178.5	73 **Ta** tantalum 180.9	74 **W** tungsten 183.8	75 **Re** rhenium 186.2	76 **Os** osmium 190.2	77 **Ir** iridium 192.2	78 **Pt** platinum 195.1	79 **Au** gold 197.0	80 **Hg** mercury 200.6	81 **Tl** thallium 204.4	82 **Pb** lead 207.2	83 **Bi** bismuth 209.0	84 **Po** polonium	85 **At** astatine	86 **Rn** radon
87 **Fr** francium	88 **Ra** radium	89–103 actinoids	104 **Rf** rutherfordium	105 **Db** dubnium	106 **Sg** seaborgium	107 **Bh** bohrium	108 **Hs** hassium	109 **Mt** meitnerium	110 **Ds** darmstadtium	111 **Rg** roentgenium	112 **Cn** copernicium		114 **Fl** flerovium		116 **Lv** livermorium		

57 **La** lanthanum 138.9	58 **Ce** cerium 140.1	59 **Pr** praseodymium 140.9	60 **Nd** neodymium 144.2	61 **Pm** promethium 144.9	62 **Sm** samarium 150.4	63 **Eu** europium 152.0	64 **Gd** gadolinium 157.2	65 **Tb** terbium 158.9	66 **Dy** dysprosium 162.5	67 **Ho** holmium 164.9	68 **Er** erbium 167.3	69 **Tm** thulium 168.9	70 **Yb** ytterbium 173.0	71 **Lu** lutetium 175.0
89 **Ac** actinium	90 **Th** thorium 232.0	91 **Pa** protactinium	92 **U** uranium 238.1	93 **Np** neptunium	94 **Pu** plutonium	95 **Am** americium	96 **Cm** curium	97 **Bk** berkelium	98 **Cf** californium	99 **Es** einsteinium	100 **Fm** fermium	101 **Md** mendelevium	102 **No** nobelium	103 **Lr** lawrencium

General information

Physical constant	Symbol	Value and units
Acceleration of free fall	g	$9.81\,m\,s^{-2}$
Avogadro constant	N_A	$6.02 \times 10^{23}\,mol^{-1}$
Elementary charge	e	$1.60 \times 10^{-19}\,C$
Electron rest mass	m_e	$9.11 \times 10^{-31}\,kg$
Neutron rest mass	m_n	$1.675 \times 10^{-27}\,kg$
Planck constant	h	$6.63 \times 10^{-34}\,J\,s$
Proton rest mass	m_p	$1.673 \times 10^{-27}\,kg$
Specific heat capacity of water	c	$4180\,J\,kg^{-1}\,°C^{-1}$
Speed of light in a vacuum	c	$3.00 \times 10^{8}\,m\,s^{-1}$
Molar gas volume (at room temperature and pressure, RTP)	V_m	$24.0\,dm^3\,mol^{-1}$
Euler's number	e	2.718

Conversion factors: $1\,eV = 1.60 \times 10^{-19}\,J$

Mathematical Equations

Circumference of circle = $2\pi r$

Area of circle = πr^2

Curved surface area of cylinder = $2\pi rh$

Surface area of sphere = $4\pi r^2$

Area of trapezium = $\frac{1}{2}(a + b)h$

Volume of cylinder = $\pi r^2 h$

Volume of sphere = $\frac{4}{3}\pi r^3$

Formulae and relationships for Unit F180

B1 Cell structure and microscopy	
Total magnification = magnification of objective lens × magnification of eyepiece lens	$M_T = M_O \times M_E$
Magnification = $\frac{\text{observed size}}{\text{actual size}}$	

B4 Biodiversity and ecosystems	
Percentage efficiency = $\frac{\text{useful energy transferred}}{\text{total energy transferred}} \times 100\%$	

C1 Atomic Structure and the Periodic Table	
Relative atomic mass = $\sum \frac{\text{(isotope mass} \times \text{isotope abundance)}}{100}$	

C2 Amount of substance	
Amount of substance = $\frac{\text{mass of substance}}{\text{molar mass}}$	$n = \frac{m}{M}$
Concentration = $\frac{\text{amount of solute}}{\text{volume}}$	$c = \frac{n}{V}$
Concentration = $\frac{\text{mass of solute}}{\text{volume}}$	$c = \frac{m}{V}$
Amount of gas = $\frac{\text{volume of gas}}{24}$	$n = \frac{V}{24}$

C4 Rates of Reaction and Enthalpy Changes	
Thermal energy = mass × specific heat capacity × change in temperature	$Q = mc\Delta\theta$

P1 Electricity	
Charge = current × time	$Q = It$
Potential difference = current × resistance	$V = IR$
Power = current × potential difference	$P = IV$
Power = (current)^2 × resistance	$P = I^2R$
Power = $\frac{\text{(potential difference)}^2}{\text{resistance}}$	$P = \frac{V^2}{R}$
Work done = potential difference × current × time	$W = VIt$
Work done = potential difference × charge	$W = VQ$
Total resistance in series = resistance of resistor 1 + resistance of resistor 2 + …	$R_T = R_1 + R_2 + \cdots$
$\frac{1}{\text{Total resistance in parallel}} = \frac{1}{\text{Resistance of resistor 1}} + \frac{1}{\text{Resistance of resistor 2}} + \ldots$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$

P2 Forces & Motion	
Work done = force × displacement	$W = Fs$
Work done = force × displacement × cos θ	$W = Fs\cos\theta$
Kinetic energy = ½ × mass × (velocity)^2	$E = \frac{1}{2}mv^2$
Gravitational potential energy = mass × acceleration of free fall × height	$E = mg\Delta h$
Elastic potential energy = ½ × force × extension = ½ × spring constant × (extension)^2	$E = \frac{1}{2}Fx$ $= \frac{1}{2}kx^2$
Power = $\frac{\text{work done}}{\text{time}}$	$P = \frac{W}{t}$
Efficiency = $\frac{\text{useful energy transferred}}{\text{total energy transferred}}$	
Net force = mass × acceleration	$F = ma$
Average velocity = $\frac{\text{displacement}}{\text{time taken}}$	$v = \frac{s}{t}$
Acceleration = $\frac{\text{final velocity} - \text{initial velocity}}{\text{time taken}}$	$a = \frac{v - u}{t}$
Final velocity = initial velocity + (acceleration × time taken)	$v = u + at$
Displacement = ½ (initial velocity + final velocity) × time taken	$s = \frac{1}{2}(u + v)t$
Displacement = (initial velocity × time taken) + (½ × acceleration × time taken^2)	$s = ut + \frac{1}{2}at^2$
Final velocity^2 = initial velocity^2 + 2 × acceleration × displacement	$v^2 = u^2 + 2as$

P3.1 Medical Physics	
Energy of a photon = Planck constant × frequency	$E = hf$
Energy of a photon = $\frac{\text{Planck constant} \times \text{speed of light in a vacuum}}{\text{wavelength}}$	$E = \frac{hc}{\lambda}$
Intensity of emergent beam = intensity of incident beam × $e^{-\text{linear attenuation coefficient} \times \text{distance travelled through the medium}}$	$I = I_0 e^{-\mu x}$
Mass attenuation coefficient = $\frac{\text{linear attenuation coefficient}}{\text{density of medium}}$	$\mu_m = \frac{\mu}{\rho}$
Density = $\frac{\text{mass}}{\text{volume}}$	$\rho = \frac{m}{V}$

Frequency = $\frac{1}{\text{time period}}$	$f = \frac{1}{T}$
Wave speed = frequency × wavelength	$v = f\lambda$
Intensity = $\frac{\text{power}}{\text{area}}$	$I = \frac{P}{A}$
Acoustic impedance = density of medium × speed of sound in the medium	$Z = \rho c$
Intensity reflection coefficient = $\frac{\text{intensity of reflected wave}}{\text{intensity of incident wave}}$ Intensity reflection coefficient = (acoustic impedance of second medium − acoustic impedance of initial medium)^2 / (acoustic impedance of second medium + acoustic impedance of initial medium)^2	$\alpha = \frac{I_r}{I_0}$ $\alpha = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2$

P3.2 Radioactivity	
Physical half-life = $\frac{0.693}{\text{radioactive decay constant}}$	$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$
$^1/_{\text{effective half-life}}$ = $^1/_{\text{physical half-life}}$ + $^1/_{\text{biological half-life}}$	$\frac{1}{t_E} = \frac{1}{t_{\frac{1}{2}}} + \frac{1}{t_B}$
Activity = radioactive decay constant × number of undecayed nuclei	$A = \lambda N$
Number of undecayed nuclei = initial number of undecayed nuclei × e$^{-\text{radioactive decay constant} \times \text{time}}$	$N = N_0 e^{-\lambda t}$
Activity = initial activity × e$^{-\text{radioactive decay constant} \times \text{time}}$	$A = A_0 e^{-\lambda t}$