SPECIMEN MATERIAL

Level 3
Applied Science

Unit 1 Key Concepts in Science

Specimen 2015 Morning 1 hour 30 minutes

Materials
For this paper you must have:
- a calculator

Instructions
- Use black ink or black ball-point pen
- Answer **all** questions
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages
- Do all rough work in this book. Cross through any work you do not want to be marked

Information
- You will be provided with a copy of the Periodic Table
- There are three sections in this paper:
  - Section A – Biology
  - Section B – Chemistry
  - Section C – Physics
- You should answer all questions in each section
- You should spend approximately 30 minutes on **each** section
- The marks for questions are in brackets

Advice
- Read each question carefully

Please write clearly, in block capitals, to allow character computer recognition.

Centre number ☐☐☐☐☐ Learner number ☐☐☐☐

Surname

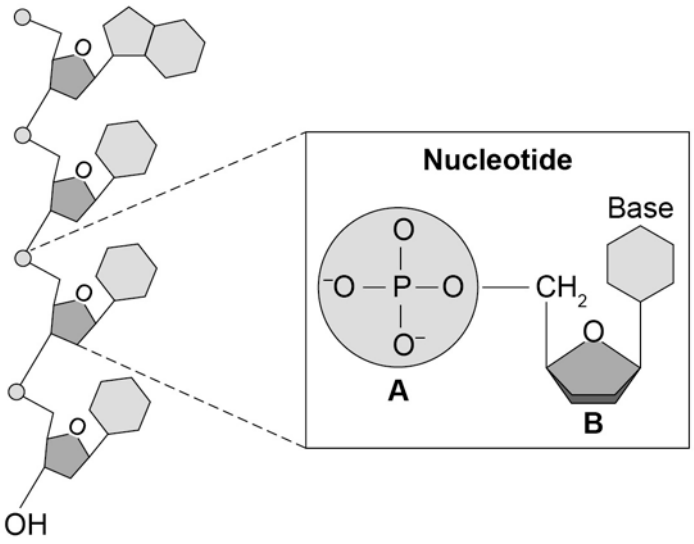
Forename(s)

Learner signature _____

Section A – Biology

1 **Figure 1** shows the structure of DNA.

Figure 1



1(a) Name parts **A** and **B** in **Figure 1**.

[2 marks]

A.....

B.....

1(b) A geneticist analysed a sample of nucleic acid and calculated the percentages of the different bases.

Table 1 shows the results of the analysis.

Table 1

Base	Percentage of base in the sample of nucleic acid (%)
Adenine	32
Cytosine	18
Guanine	18
Uracil	32

The information in **Table 1** showed the geneticist that the sample was double-stranded ribonucleic acid (RNA).

1(b)(i) Use the information in **Table 1** to explain how the geneticist knew that the sample was RNA and **not** DNA.

[1 mark]

……

……

1(b)(ii) Use the information in **Table 1** to explain how the geneticist knew that the sample was double-stranded rather than single-stranded.

[2 marks]

……

……

……

……

1(c) The percentage of thymine in a sample of DNA is 21%.

Calculate the percentage of cytosine in the same sample of DNA.

[2 marks]

……

……

……

Percentage = ……...

Total 7 marks

TURN OVER FOR THE NEXT QUESTION

2 A man is admitted to hospital with arrhythmia of the heart. A nurse tests the man's blood pH and blood glucose.

2(a)(i) State the normal healthy ranges for blood pH and blood glucose.

[2 marks]

Blood pH = ……

Blood glucose = ……mg/dL

2(a)(ii) The man's blood pH is lower than the healthy range.

Describe how the human body detects a decrease in blood pH.

[2 marks]

……

……

……

……

2(b) The nurse thinks that the man's sinoatrial node is not working correctly. She suggests that the man should be fitted with an artificial pacemaker like the one shown in **Figure 2**.

Figure 2

Describe how the artificial pacemaker causes the heart to beat.

[6 marks]

……

……

……

……

……

……

……

……

……

……

……

……

QUESTION 2 CONTINUES ON THE NEXT PAGE

2(c) Artificial pacemakers like the one shown in **Figure 2** have been used to correct heart arrhythmias for many decades, but complications can occur with their use.

The information below is about a new type of artificial pacemaker.

> The new artificial pacemaker has its pulse generator within the unit in the heart.
>
> The wireless unit is smaller than a triple-A battery and it is faster and easier to implant than traditional pacemakers. The device is implanted through the femoral vein in the leg and is attached to the heart in the right ventricle, the same place a traditional lead would be attached.
>
> A study of the new pacemaker was conducted using 33 patients at two different hospitals. The average age of the patients was 77, and two-thirds of the patients were men. The self-contained pacemaker was successfully implanted in 32 patients. One patient had complications during the procedure and later died after suffering a stroke.
>
> Researchers reported that after three months, the new pacemakers were functioning well and that 94% of the patients were free of complications throughout the three-month study period.
>
> The researchers are continuing to track the patients and expect to report longer-term outcomes later this year.

Suggest **three** possible **disadvantages** of using the new type of artificial pacemaker.

[3 marks]

1……

……

2……

……

3……

……

Total 13 marks

Section B – Chemistry

3 This question is about elements in the Periodic Table.

3(a) Element **X** is a highly reactive gas. It exists as covalently bonded molecules.
Element **Y** is a good conductor of electricity that forms a green carbonate solution.
Element **Z** is a reactive metal that burns with a white flame.

Complete **Table 2** to show where each element, **X**, **Y** and **Z**, belongs in the Periodic Table.

[2 marks]

Table 2

Element	Part of Periodic Table
	s block
	group VII
	group 0
	d block

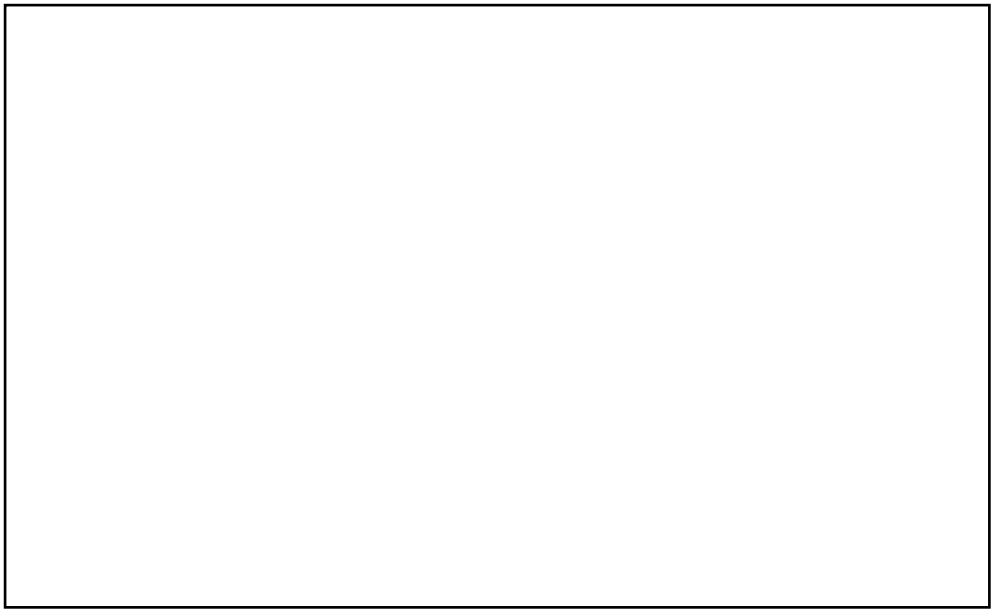
QUESTION 3 CONTINUES ON THE NEXT PAGE

3(b) Some elements can exist in different structural forms called allotropes.

Graphene is an allotrope of carbon. It has properties which make it useful as a semiconductor and in composite materials.

3(b)(i) Draw a diagram showing the structure of graphene.

[1 mark]



3(b)(ii) State the type of bonding between carbon atoms in graphene.

[1 mark]

.....

3(b)(iii) Describe the arrangement of particles in graphene.

[1 mark]

.....

.....

3(b)(iv) Explain why graphene is a good conductor of electricity.

[2 marks]

.....

.....

.....

.....

3(b)(v) Name **one** other allotrope of carbon which has similar electrical conductivities to graphene.

[1 mark]

.....

Total 8 marks

4 When anhydrous sodium carbonate is added to dilute hydrochloric acid, carbon dioxide gas is produced. The sodium carbonate dissolves to give a solution of sodium chloride, which gives off heat.

$$Na_2CO_3\,(s) + 2HCl\,(aq) \rightarrow 2NaCl\,(aq) + H_2O\,(l) + CO_2\,(g)$$

4(a)(i) Draw a labelled energy profile for this reaction on the grid below.

[3 marks]

4(a)(ii) Calculate the relative molecular mass of anhydrous sodium carbonate.
(Relative atomic masses: Na = 23, C = 12, O = 16)

[1 mark]

.....

Relative molecular mass = ...

4(a)(iii) Use your answer to part (a)(ii) to calculate the number of moles in 1.00 g of anhydrous sodium carbonate.

[1 mark]

.....

.....

4(b) A chemist added 1.00 g of sodium carbonate to 50 cm^3 of hydrochloric acid of concentration 1.00 mol dm^{-3}. The temperature rise of the solution was 5.1 ^oC.

Calculate the heat energy transferred in the reaction. Use the formula $q = mc\Delta T$

Assume that the density of the solution is 1 g cm^{-3} and that it has a specific heat capacity of 4.18 J $K^{-1}g^{-1}$.

[1 mark]

.....

Heat energy = ...

Total 6 marks

5 Analytical scientists use titration to find the concentration of an acid or a base (alkali).

A chemist titrated 25 cm^3 of 0.1 M ammonia solution against dilute hydrochloric acid. The pH was measured at intervals as the acid was added from a burette.

$$NH_3\ (aq) \quad + \quad HCl\ (aq) \quad \rightarrow \quad NH_4Cl\ (aq)$$

The results of the titration are shown in **Table 3**.

Table 3

Volume of acid added (cm^3)	pH of solution
0.00	10.8
4.00	9.7
8.20	9.5
12.00	9.3
16.00	8.8
18.00	8.4
19.30	8.0
19.90	7.2
20.00	3.4
20.30	3.0
22.00	2.0
24.00	1.9
26.00	1.9

5(a)(i) Plot the results from **Table 3** on the grid below, using appropriate scales, and draw a line of best fit.

[2 marks]

5(a)(ii) Use your graph to determine the volume of acid needed to exactly neutralise the ammonia solution.

[1 mark]

Volume = ……cm^3

5(a)(iii) Use your graph to determine the pH at the end point.

[1 mark]

pH = ...

QUESTION 5 CONTINUES ON THE NEXT PAGE

5(b) When carrying out a titration it is important to use the correct indicator. The indicator should change colour at a pH close to the end point of the titration.

Table 4 shows the pH ranges at which some indicators change colour.

Table 4

Indicator	Colour in acid	Colour in alkali	pH range for colour change
Litmus	Red	Blue	6.2—8.2
Phenolphthalein	Colourless	Pink	8.2—10.0
Methyl red	Red	Orange	4.2—6.6
Bromothymol blue	Yellow	Blue	6.0—7.6

Using the information in **Table 4**, identify the most suitable indicator for the reaction between ammonia solution and dilute hydrochloric acid. Explain your choice.

[2 marks]

.....

.....

.....

.....

Total 6 marks

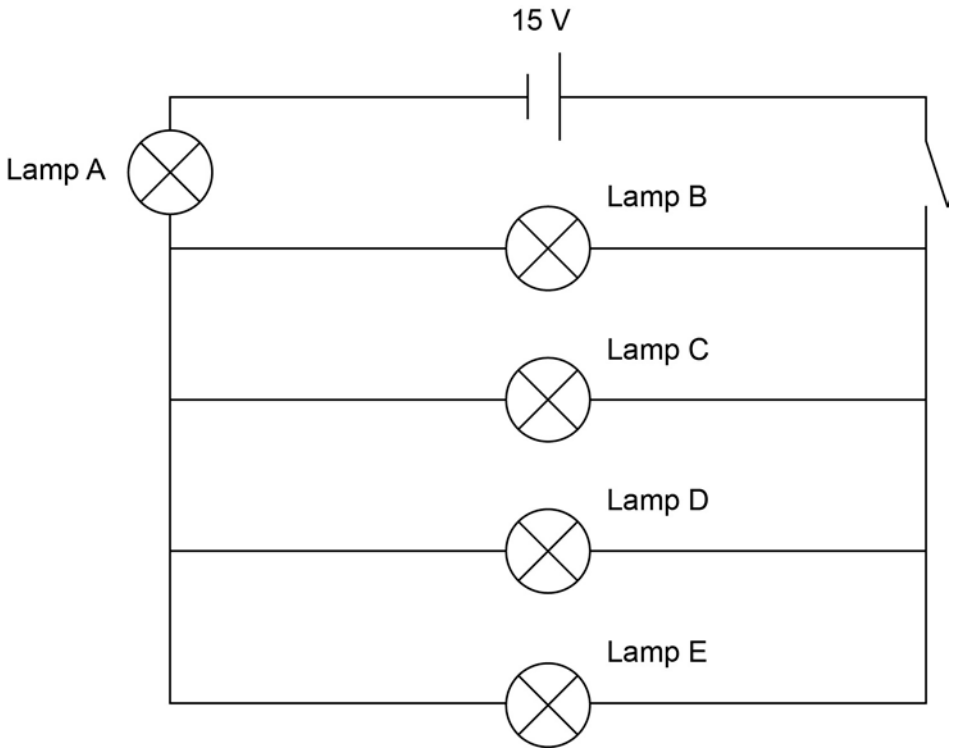
TURN TO PAGE 14 FOR THE NEXT QUESTION

BLANK PAGE WORDING

Section C – Physics

6 A toymaker is designing a circuit for lighting in a dolls' house.
The circuit design is shown in **Figure 3**.

Figure 3



6(a)(i) Calculate the total resistance of the circuit. Assume that each lamp has a resistance of 6 Ω.

Use the formulas given below:

resistors in parallel $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$

resistors in series $R_T = R_1 + R_2 + R_3 + ...$

[3 marks]

Total resistance = ……. Ω

6(a)(ii) Read the statements below about lamp E in **Figure 3**. One of the statements is correct.

A The potential difference across lamp E is 15 V.

B The potential difference across lamp E is one quarter of the potential difference across lamp A.

C The current flowing through lamp E is equal to the current flowing through lamp A.

D The current flowing through lamp E is one quarter of the current flowing through lamp A.

Write the letter for the correct statement in the box below.

[1 mark]

6(b) The toymaker wants to be able to vary the brightness of lamp E.

Add a component to **Figure 3** which would allow lamp E to be operated with a dimmer switch. Label this component **X**.

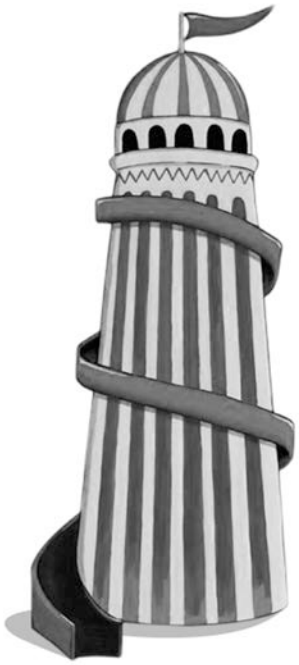
[1 mark]

Total 5 marks

TURN OVER FOR THE NEXT QUESTION

7 An engineer is checking the plans for a new fairground helter-skelter, like the one shown in **Figure 4**.

Figure 4



7(a) The gravitational potential energy (GPE) of a person, mass 60 kg, when they are at the top of the helter-skelter is 11 772 J.

Identify the theoretical maximum velocity the person would have when they reach the bottom of the helter-skelter. Use the formula $E_k = \frac{1}{2}mv^2$

A 9.9 m s^{-1}

B 19.8 m s^{-1}

C 186.4 m s^{-1}

D 392.4 m s^{-1}

Write the correct letter in the box below.

[1 mark]

7(b) The engineer is concerned that riders may be injured by impact with the concrete ground when they reach the end of the helter-skelter. She decides that a soft surface needs to be installed. She considers using either a 30 cm thick foam mat or a 30 cm depth of sand.

Use your knowledge of momentum to explain why a soft surface at the end of the slide would make the helter-skelter safer, and discuss whether a foam mat or sand would be most effective.

[6 marks]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Total 7 marks

TURN OVER FOR THE NEXT QUESTION

8(a) An architect is designing a new energy-efficient house for a client. The client lives in a sunny area, so the architect suggests that the house should use solar energy to provide both hot water and electricity. Photovoltaic cells and solar thermal panels are two ways of using solar energy.

8(a)(i) Describe the role of photovoltaic cells and solar thermal panels.

[2 marks]

Photovoltaic cells.....

.....

Solar thermal panels.....

.....

8(a)(ii) Explain why solar thermal panels are covered with **black** glass.

[1 mark]

.....

.....

8(b) The architect also suggests that the client should install a small wind turbine to provide additional electricity.

8(b)(i) State **one** advantage of using a small wind turbine rather than a solar-powered device to generate electricity.

[1 mark]

.....

.....

8(b)(ii) Explain why wind turbines cannot be used during very high winds.

[2 marks]

.....

.....

.....

.....

8(b)(iii) State **two** other disadvantages of using a small wind turbine rather than a solar-powered device to generate electricity.

[2 marks]

1.....

.....

2.....

.....

Total 8 marks

END OF QUESTIONS