



HARROW SCHOOL

ENTRANCE SCHOLARSHIPS EXAMINATION 2017

BIOLOGY

Time allowed: 30 minutes

Total mark: 33

GENERAL INSTRUCTIONS:

Answer all questions in the spaces provided.

You may use a calculator.

Question 1

Answer the following multiple-choice questions. Underline the correct answer with a ruler and pencil as shown in the example below:

Example question: What is the maximum magnification that can be achieved using a standard light microscope when the magnification of the eyepiece lens is x10 and the magnification of the high power objective lens is x40?

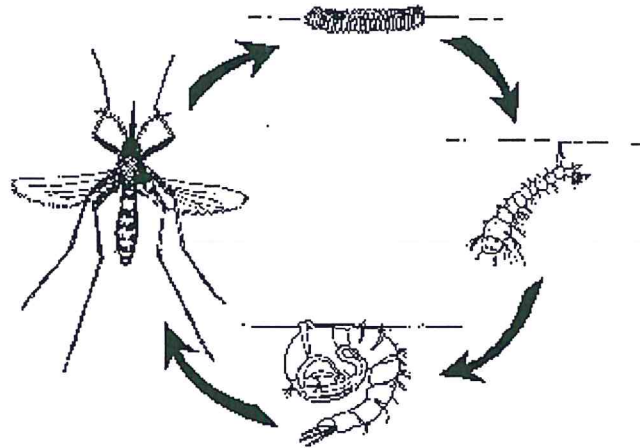
- i. x40
 - ii. x50
 - iii. x400
 - iv. x410
- a) What is the correct order of different types of teeth from the front of the mouth to the back? (1)
- i. canines → incisors → pre-molars → molars
 - ii. incisors → canines → pre-molars → molars
 - iii. incisors → canines → molars → pre-molars
 - iv. canines → incisors → molars → pre-molars
- b) Which group of vertebrates evolved first? (1)
- i. reptiles
 - ii. mammals
 - iii. fish
 - iv. amphibians
 - v. birds
- c) Which of the following organisms is not a type of fish? (1)
- i. shark
 - ii. ray
 - iii. eel
 - iv. whale
- d) In the UK, 9.6 million adults smoke (= 19% of the adult population). What is the size of the adult population in the UK? (1)
- i. 65.2 million
 - ii. 50.5 million
 - iii. 1.8 million
 - iv. 11.4 million

- e) Which of the following cancers does not affect women? (1)
- i. oesophageal cancer
 - ii. prostate cancer
 - iii. breast cancer
 - iv. cervical cancer
- f) What is the correct word equation for photosynthesis? (1)
- i. glucose + oxygen → carbon dioxide + water
 - ii. oxygen + carbon dioxide → glucose + water
 - iii. oxygen + water → glucose + carbon dioxide
 - iv. water + carbon dioxide → oxygen + glucose
- g) Which of the following diseases is not caused by bacteria? (1)
- i. cholera
 - ii. flu
 - iii. typhoid
 - iv. tuberculosis
- h) Which scientist was the pioneer of the smallpox vaccine; the world's first vaccine? (1)
- i. Louis Pasteur
 - ii. Charles Darwin
 - iii. Edward Jenner
 - iv. Alexander Fleming
- i) For how many weeks, on average, does pregnancy in humans last? (1)
- i. 9 weeks
 - ii. 12 weeks
 - iii. 24 weeks
 - iv. 38 weeks

/ 9 marks

Question 2

Mosquitoes are small insects. They start out life as eggs which the females lay on water. The eggs hatch into swimming larvae. Once they reach a large enough size, the larvae become pupae from which the flying adults emerge to breed and the life cycle begins again.



- a) State two characteristics that mosquitoes share with all other types of insect. (2)

.....

- b) The diagram above shows the life cycle of a mosquito. Add the following labels to the diagram: *pupa*, *egg*, *larva*, *adult*. (1)

- c) Name two other types of insect that undergo a similar life cycle. (2)

.....

Mosquito larvae feed on algae, bacteria and other microorganisms in the water. Adult mosquitoes feed on nectar and other sugary sap. Mosquitoes are prey for many different animals. In particular, mosquito larvae are eaten by small fish and adult mosquitoes are eaten by small birds, dragonflies and frogs.

- d) Draw a food chain below that includes the mosquito larva. (1)

- e) Draw a food chain below that includes the adult mosquito. (1)

In addition, adult female mosquitoes feed on blood. In order to obtain a blood meal, a female mosquito uses her mouthparts to pierce the skin of the animal host, such as a human, and suck up its blood. Through feeding on blood in this way, female mosquitoes can transmit diseases such as malaria. If they bite an infected person they may pick up the microorganism that causes the disease and transfer it to the next person that they bite.

f) Suggest why adult female mosquitoes need a blood meal. (2)

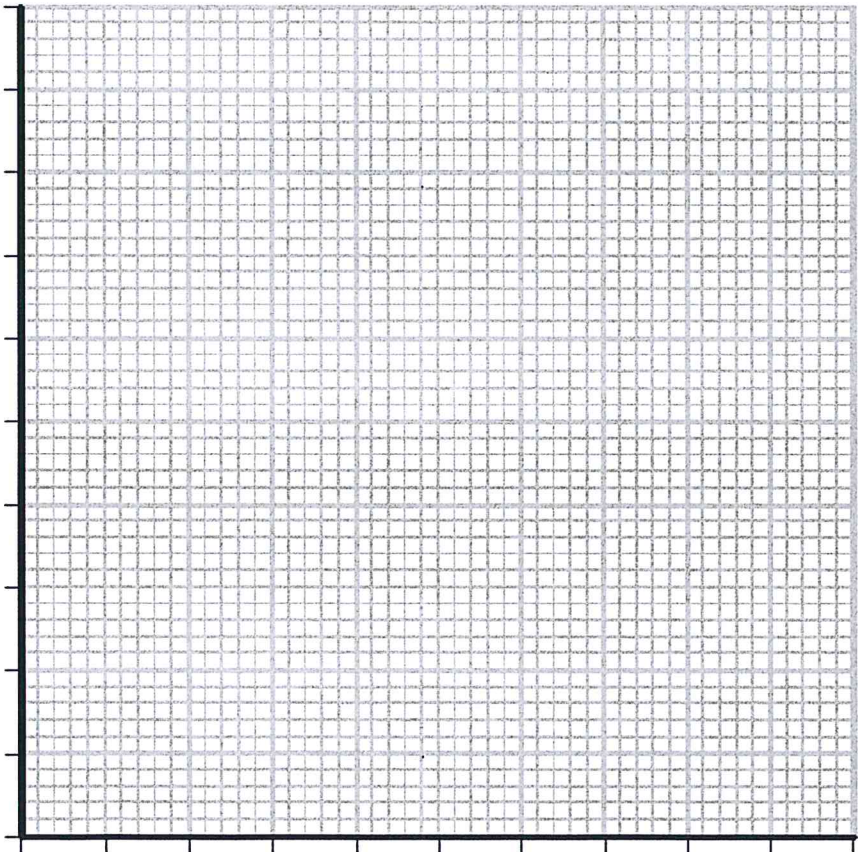
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The table below shows how the number of deaths from malaria per 100 000 people (the annual mortality rate) changed over the course of the 20th century.

Year	Annual mortality rate per 100 000 people
1900	194
1930	174
1950	48
1970	16
1990	17
1997	18

g) Plot the data in a suitable graph or chart below. (5)



- h) Explain why it is more useful to measure the number of deaths from malaria *per 100 000 people* than simply the total number of deaths. (2)

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.....

- i) Calculate the percentage decrease in the annual mortality rate between 1930 and 1950? Show your working. (2)

Answer =%

One reason for the decrease in the annual mortality rate from malaria is that areas such as ponds and buildings near to where people live have been sprayed with insecticide which kills mosquitoes.

- j) Suggest what negative impacts spraying insecticide might have on the food web. (2)

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- k) Suggest two other reasons for the decrease in the annual mortality rate from malaria. Explain your answers. (4)

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/ 24 marks



HARROW SCHOOL

ENTRANCE SCHOLARSHIPS EXAMINATION 2017

CHEMISTRY

30 Minutes

GENERAL INSTRUCTIONS:

Answer all questions in the spaces provided.

You may use a calculator.

1. This question is about solids, liquids, and gases.

- a) We are very familiar with the conversion of ice into water, and water into steam. Ice melts to form water at 0 °C (the melting point of ice) and water boils to form steam at 100 °C (the boiling point of water).

What state will water be in at

- i. 25 °C

..... [1]

- ii. 110 °C

..... [1]

- b) Other substances also melt and boil, but will not do so at the same temperatures.

Complete the following table to show the states of the following substances at room temperature (25 °C)

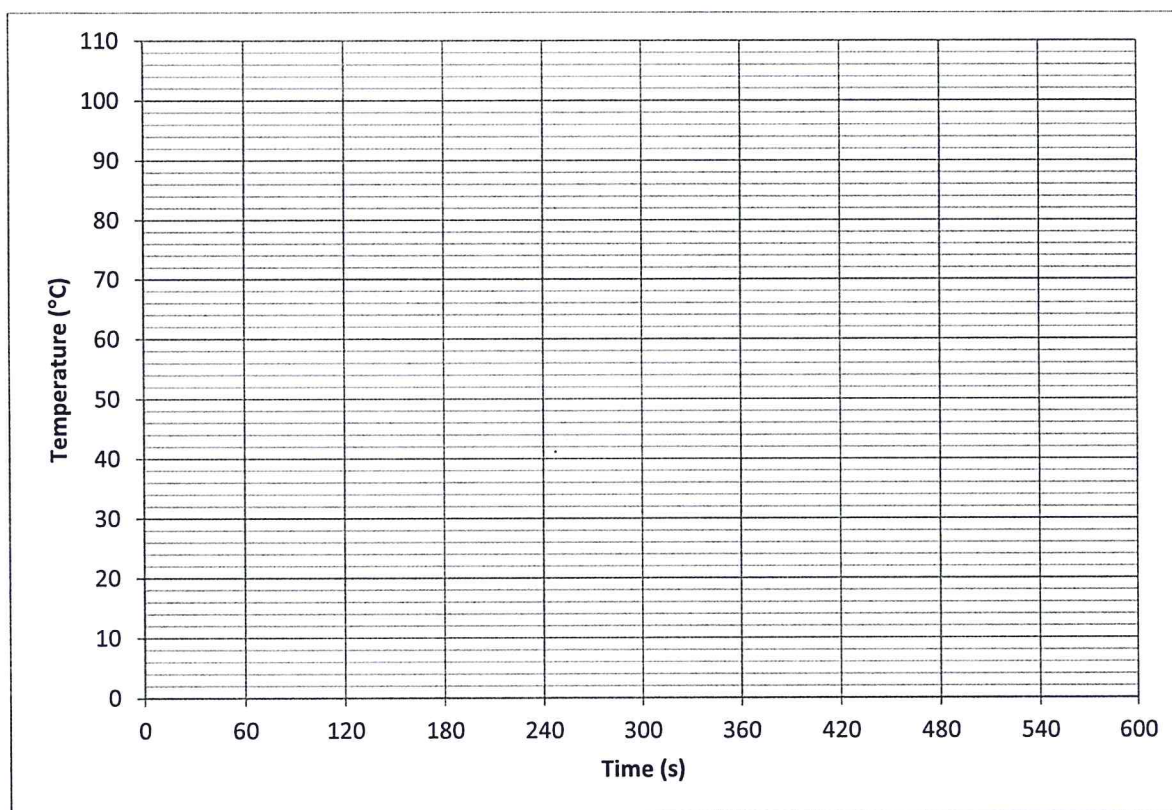
Substance	Melting Point	Boiling Point	State at 25 °C
ethanol	-114 °C	78 °C	.....
ammonia	-78 °C	-33 °C	.....
gallium	30 °C	2400 °C	.....

[3]

- c) The data below shows how the temperature of another substance, stearic acid, varies as it is heated over the temperature range of 25 °C to 100 °C. At 25 °C it is a solid.

Time (s)	Temperature (°C)
0	25
60	41
120	55
180	69
240	69
300	69
360	69
420	69
480	78
540	88
600	100

- i. Plot the data on the following axes. Join the points to form a smooth curve.



[3]

- ii. What do you think is happening to the stearic acid when the graph is horizontal?

.....

[1]

- i. What is meant by the term “molecule”?

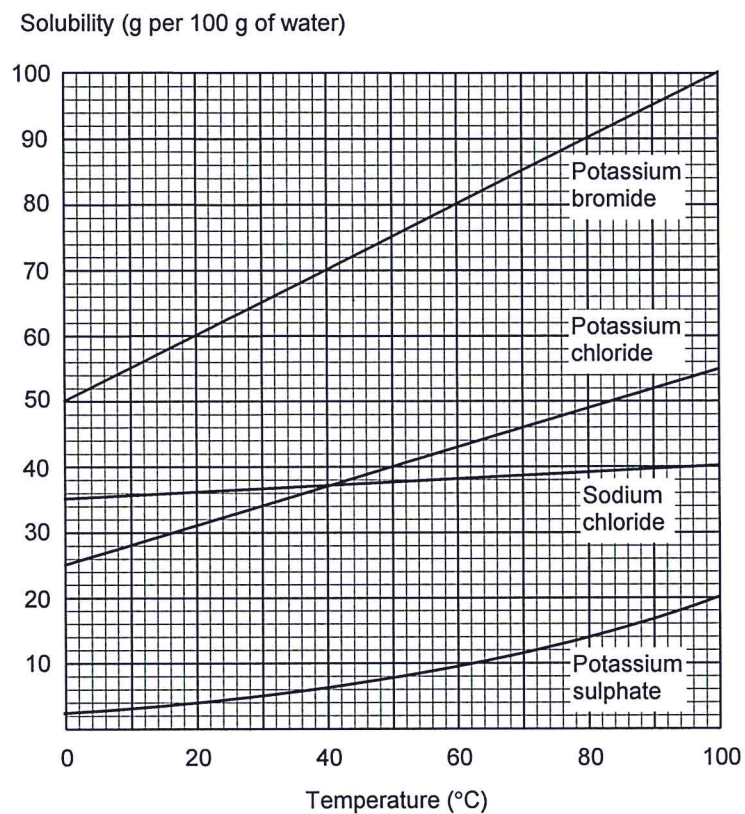
Molecular substances are held together as liquids by the forces that form between the molecules. These forces vary in strength. To turn a liquid into a gas, the forces between the molecules have to be broken.

- atoms large strong small

The forces between the
are and require
a amount of energy to be
broken.

[Total 13 marks]

2. Water is a very useful solvent. It dissolves many substances, but some solutes are more soluble than others. The graph shows the solubility of four solid compounds in water at various temperatures. It shows the mass of solid needed for the solution to become fully saturated. All solids follow this same trend.



- a) State the trend of a solid's solubility in water with changing temperature.

.....

.....

.....

[1]

- b) i. Which substance is least soluble at 40°C?
..... [1]
- ii. At what temperature will 70 g of potassium bromide dissolve in 100g water?
..... [1]
- iii. What is the solubility of potassium chloride at 80°C?
..... [1]
- iv. What is the solubility of potassium chloride at 40°C?
..... [1]
- c) What would you observe if a solution of potassium chloride (in 100g water) was cooled from 80°C to 40°C? Explain your answer.
.....
.....
.....
..... [2]
- d) i. Which chemical's solubility is least affected by temperature?
..... [1]
- ii. Which chemical's solubility is most affected by temperature? Explain your answer.
.....
.....
.....
..... [2]

[Total 10 marks]

3. This question is about the periodic table, atomic structure, and chemical reactivity.

You may not have been taught the material relating to these questions, however, you should be able to answer these questions by thinking about the information that you have been presented with, and by using the chemical knowledge that you have gained so far.

Of the elements in the periodic table, there are two major types - *metals* and *non-metals*.

Copper is an example of a metal element. If left exposed in dry air, copper will react with a non-metal in the air.

- a) Explain clearly what is meant by the terms

- i. element

..... [1]

- ii. compound

..... [1]

- b) i. Which element in the air is reacting with the copper?

..... [1]

- ii. Predict the name of the compound formed by the reaction of copper in air.

..... [1]

- c) The periodic table is a tabular arrangement of atomic chemical elements, where the elements are ordered by increasing numbers of a sub-atomic particle called a proton.

Atoms consist of three sub-atomic particles:

	relative charge	relative mass
electron	-1	almost zero
proton	+1	1
neutron	0	1

All of the atoms in the periodic table have:

- no charge overall (*they are 'charge neutral'*)
- a mass number, which is equal to the number of protons plus the number of neutrons.
(*Mass number = number of protons + number of neutrons*)

Using the above information, complete the following table:

Element	Symbol	Mass Number	Number of Protons	Number of Neutrons	Number of Electrons
Hydrogen	H	1	1	0	.....
Carbon	C	.....	.....	6	6
Chlorine	Cl	35	.....	18	17
Copper	Cu	.....	29	34	.....

[6]

- d) As a result of the reaction of copper in air mentioned earlier, the copper atoms react by losing electrons, turning into something called an *ion*. Ions are charged particles because they do not have equal numbers of protons and electrons.

Would you expect the copper ion to have positive or negative charge after this reaction? Explain your answer.

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[2]

[Total 12 marks]



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ENTRANCE SCHOLARSHIPS EXAMINATION 2017

PHYSICS

30 Minutes

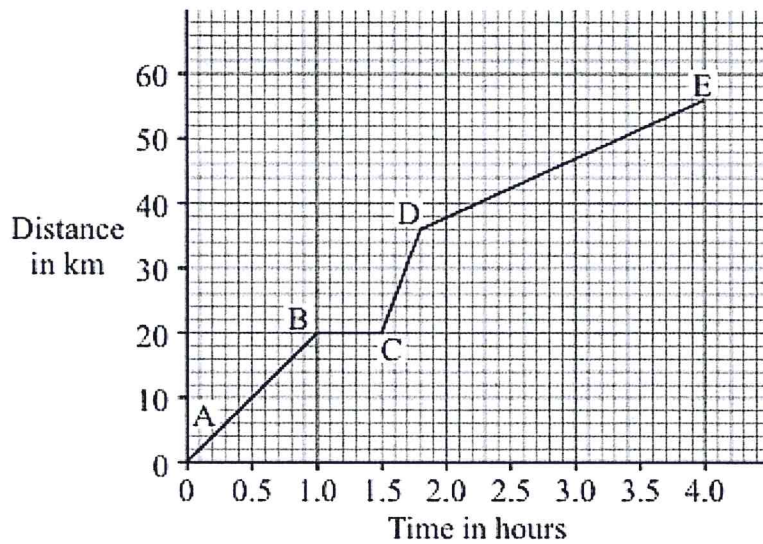
GENERAL INSTRUCTIONS:

Answer all questions in the spaces provided.

All Working must be shown.

You may use a calculator if you wish.

- Q1.** A cyclist goes on a long ride. The graph shows how the distance travelled changes with time during the ride.



- (i) Between which **two** points on the graph was the cyclist moving at the fastest speed?
 (1)
- (ii) State **one** way cyclists can reduce the air resistance acting on them.

 (1)
- (iii) How long did the cyclist stop and rest?
 (1)
- (iv) Write down the equation which links distance, speed and time.
 (1)
- (v) Calculate, in *km/hr*, the average speed of the cyclist **while moving**.

Average speed = *km/hr* (3)

(Total 7 marks)

- Q2.** Joel is informed by his Physics teacher, Mr Jeffers, that there are a few 'rules' concerning electric circuits that are very useful when trying to figure out what the values of current and voltage are at different points in a given circuit:

RULE 1: *The sum of the electric currents flowing out of a junction in a circuit is equal to the sum of the currents flowing into the junction.*

RULE 2: *The sum of the voltages across components connected in series around a circuit is equal to the total voltage provided by the battery.*

RULE 3: *The voltage across any components connected in parallel with each other is always the same for each component.*

- a. For each of the statements i. to vii below, fill in the blank with the word or term from the box which best completes the sentence. Each word or term in the box may be used once, more than once or not at all.

amps	volts	voltage	in series	in parallel	hertz
watts	after	before	current	power	energy
low	high	electricity	electric charge		

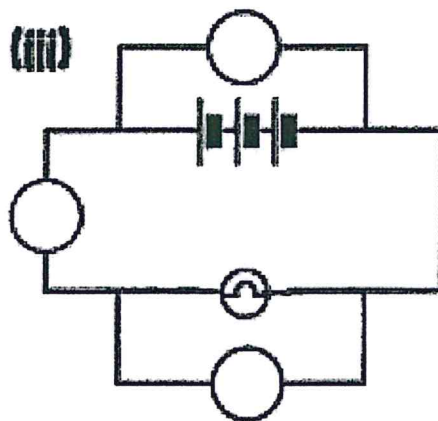
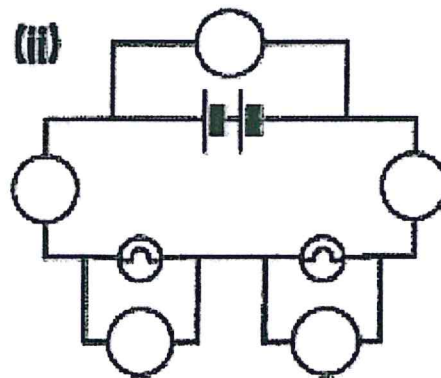
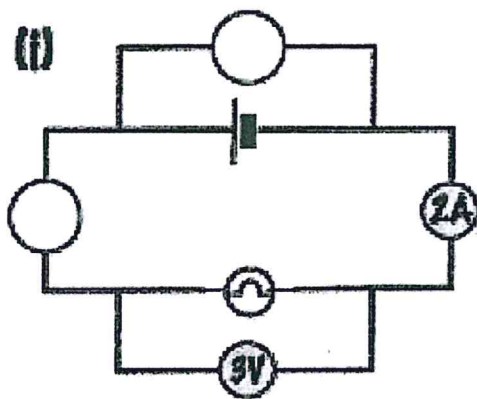
- i. An ammeter should always be connected _____ with the component
- ii. An ammeter measures electric current in _____.
- iii. A voltmeter measures the quantity _____ in _____
- iv. A voltmeter should be connected _____ with the component
- v. An 'electricity bill' charges you for the amount of _____ you have used.
- vi. An ammeter should have a very _____ resistance
- vii. A voltmeter should have a very _____ resistance

- b. In the circuit diagrams below, **all the components are identical**. In other words, the bulbs and cells in all three diagrams below are exactly the same.

Use the information given in each circuit, and the rules of circuits described by Mr Jeffers, to write in the missing values of current and voltage in each of the 'empty' meters below.

One of the ammeters (reading **2A**) and one of the voltmeters (reading **3V**) in diagram (i) have been filled in already to get you started.

Don't forget to include the unit (A or V) in which each of your values is measured!



(6)

(Total 14 marks)

Q3. For this question it might be useful to recall a few things about circles and cylinders:

- i. The diameter, D , of a circle is twice its radius, r
- ii. The circumference of a circle = $2 \pi r$
- iii. The area of a circle is πr^2
- iv. The volume of a cylindrical wire is $\pi r^2 L$, where L is the length of the wire.
- v. You can, if you wish, approximate the value of π to 3.14

When a tensile (that is 'pulling') force is applied to a wire, the wire stretches.

How much the wire stretches, called the *extension*, x , depends on a number of factors:

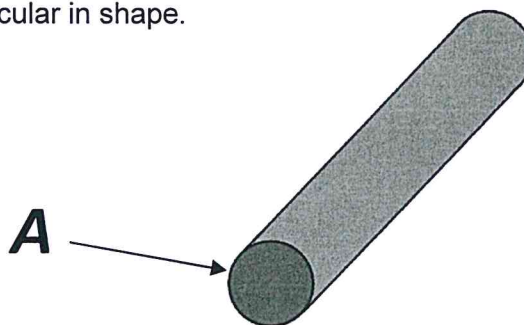
- The magnitude of the force pulling it, F
- The cross-sectional area, A , of the wire
- The original (that is, unstretched) length, L , of the wire
- The material the wire is made of

Bob takes a length of very thin copper wire. He wants to know its length but has forgotten to bring his ruler! However, he has a drinking straw in his lunchbox and he uses a sheet of graph paper to measure the diameter of the straw to be 8 mm . He then finds that if he winds his length of wire around the straw it takes 48 turns.

- a. What is the length, L , of his wire? Show your working clearly.

(3)

Bob next looks at the cross section of the wire using a magnifying glass and sees that the cross-sectional area, A , is circular in shape.



Bob's teacher tells him that this particular wire has a diameter of 0.52 mm .

- b. Calculate the cross-sectional area, A , of the wire. Don't forget to include a unit.

(3)

The extension of the wire is directly proportional to the applied force (provided the force isn't too large). Bob's teacher tells him that this particular wire stretches by 1 mm for every 90 N of force applied to it.

- c. What will be the new length of Bob's wire if it is stretched by a force of 270 N ?

(3)

Bob reads in his physics textbook that the extension of a stretched wire is inversely proportional to its cross-sectional area.

- d. If Bob had used a piece of copper wire of the same initial length but with only half the diameter of his original wire, how far would it have stretched with the same 270 N force applied?

(3)

(Total 12 marks)



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MATHEMATICS I

90 Minutes

GENERAL INSTRUCTIONS:

*You may attempt all questions if you have time,
but greater credit will be given for complete solutions.*

Show all your working.

Calculators may be used.

1. You are given that

$$C = \frac{47.7 \times 189}{2.09}.$$

- a. ESTIMATE the value of C , giving your final answer to 1 significant figure.
- b. Using your calculator, work out the value of C , giving your answer correct to the nearest whole number.
- c. Explain why your estimate is greater than the calculated value of C .
- d. Calculate the percentage error between the estimate of C and its calculated value, giving your answer to the nearest %.

2. Mr Bellefonte sold 30 pairs of shoes today. He made £4.50 profit on each of ten pairs. He made £3.55 profit per pair on fourteen pairs. He made £2.80 per pair on the remaining shoes.
- Find the mean profit that Mr Bellefonte made on a pair of shoes today.
 - Mr Bellefonte buys 500 pairs of shoes at £120 each. He wants to sell them all for £135 each.
 - What is the least number of pairs that need to be sold in order for him to recover his costs?
 - Calculate his percentage loss if he only sells 375 pairs of shoes at £135 each.

3. Simplify the following:

a. $q^7 - q^4$

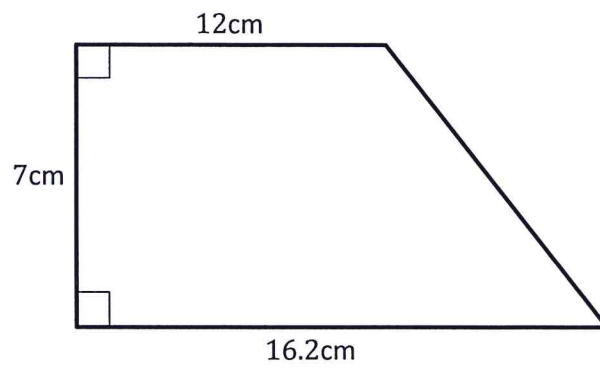
b. $8a^2 - a^4$

c. $12r^6 \div 2r^4$

d. $\frac{(3ab)^2}{9a^2}$

e. $\frac{3t-3r}{r-t}$

4. A wire is bent into the trapezium below (NB the diagram is not to scale):



- Calculate the length of the wire.
- The wire is now reshaped into a circle. Calculate the area of the circle.

5. Solve the following equations:

a. $4(5x - 3) = 8 - 3x$

b. $\frac{5}{2} - \frac{x-2}{5} = \frac{1}{2}$

c. $4 + \frac{3-x}{x} = \frac{2}{x}$

6. A company makes laptops.

The total cost, $\pounds C$, to make n laptops is given by the formula

$$C = a + bn,$$

where a and b are constants.

The cost of making 200 laptops is $\pounds 41095$.

The cost of making 370 laptops is $\pounds 75605$.

Calculate the values a and b and work out the cost of one computer.

7. On a motoring holiday in Poland, I expect to drive 600 miles. Petrol costs €1.08 per litre in Poland. The rate of exchange is €1.16 for £1, and my car averages 35 miles per gallon of petrol. Using the approximate relations:

$$5 \text{ miles} = 8 \text{ kilometres, } 4.5 \text{ litres} = 1 \text{ gallon}$$

where necessary, calculate:

- a. The price of petrol in Poland, expressed in pounds per gallon;
- b. The amount of money (in pounds) which I expect to spend on petrol during my time in Poland;
- c. The rate of petrol consumption of my car, expressed in litres per 100km.

8. a. Simplify the following:

i. $a(b + 7) + b(5 - a)$

ii. $\frac{x}{4} + \frac{7}{12}$

b. Solve

i. $4x - 50 \leq 30$

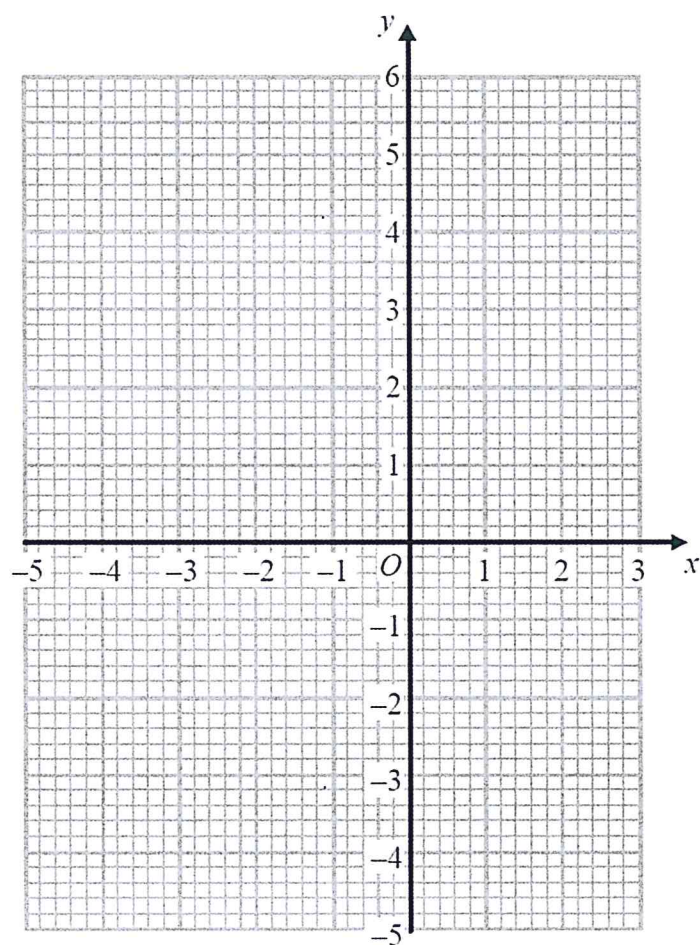
ii. $\frac{x}{2} + 8 > \frac{x}{3} + 10$

c. Write down all the multiples of 5 which satisfy both of the inequalities in part (b)

9. Complete the table of values for $y = x^2 + 2x - 3$.

x	-4	-3	-2	-1	0	1	2
y							

a. On the grid, draw the graph of $y = x^2 + 2x - 3$ for values from -4 to 2 .



b. Use your graph to solve $x^2 + 2x - 3 = 0$

c. By plotting the line $y = 2x - 1$, use your graph to solve the equation $x^2 + 2x - 3 = 2x - 1$

d. For what values of x is $y > 1$?



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ENTRANCE SCHOLARSHIPS EXAMINATION 2017

MATHEMATICS II

90 Minutes

GENERAL INSTRUCTIONS:

You may attempt all questions if you have time, but greater credit will be given for complete solutions.

Show all your working.

Calculators may NOT be used.

PLEASE NOTE: This paper is not just about getting the right answers; correct answers on their own will earn few marks. You will be marked more on the PRESENTATION of your solutions, the EXPLANATION of your working and the JUSTIFICATION of your final answers.

This paper is very difficult. You will earn more credit for complete solutions to the questions you do (even if you don't do them all), rather than incomplete attempts at solutions to all the questions.

Note: none of these questions requires a "trial and improvement" approach; they can all be solved by other means.

1. 2 dogs eat 3 bags of food in 4 days. How many days would it take 3 dogs to eat 4 bags of food?
2.
 - a. Write 1008 as a product of prime factors.
 - b. N is a whole number. 1008 is the lowest common multiple of 8, 9 and N . What are all the possible values of N ?

3. Solve the following pairs of simultaneous equations:

a. $32a + 15b = 3$; $20a - 9b = 8$

b. $\frac{32}{x} + \frac{15}{y} = 3$; $\frac{20}{x} - \frac{9}{y} = 8$

4. $ABCD$ is a square. E is a point outside $ABCD$ such that the triangle BCE is equilateral.

What is the size of angle BEA ? Remember to explain all your reasoning carefully.

5. In this question, the operation $a \bowtie b$ is defined as $a \bowtie b = \frac{1}{ab}$ (where $a, b \neq 0$). For example, $5 \bowtie 6 = \frac{1}{5 \times 6} = \frac{1}{30}$.

- a. Find:

i. $-4 \bowtie 5$;

ii. $\frac{1}{2} \bowtie \frac{2}{3}$;

iii. $(2 \bowtie 3) \bowtie 4$;

iv. $2 \bowtie (3 \bowtie 4)$.

- b. What do your answers to parts (iii) and (iv) tell you about the operation \bowtie ?

- c. Simplify:

i. $x \bowtie \frac{1}{x}$;

ii. $(3 \bowtie x) \bowtie x$.

- d. Solve $3 \bowtie (x \bowtie x) = 12$.

6. The number M is a whole number which is not equal to 1 (M may be positive or negative). The number $\frac{M+3}{M-1}$ is also a whole number (which may be positive or negative).

What are the possible values for M ?

7. In a race, two cars are driving at 100km/h and are neck-and-neck. With 15km to go, one of the cars has a puncture and has to slow down to 40km/h. The other car continues at 100km/h and wins the race. The car with the puncture comes second.

The second car's total time for the whole race was twice as long as the winning car's time for the whole race.

What was the total distance of the race?

8. These questions are about divisibility.

- a. Take an even number. If you multiply it by 4 then you get the number P . If you half it then you get the number Q . $P - Q$ is always a multiple of seven.

For example, if we choose 10, then $P = 40$ and $Q = 5$. $40 - 35 = 35$, which is a multiple of seven.

Explain why, regardless of which even number you start with, you will always get a multiple of seven.

- b. Take a multiple of four. If you half it you get the number R . If you triple it you get the number S .

The number $S - R$ is always the multiple of a particular odd number, regardless of what number you start with. What is this odd number? (Remember you must prove that this is the case.)