OUNDLE

School

2016 Academic Scholarship

Science

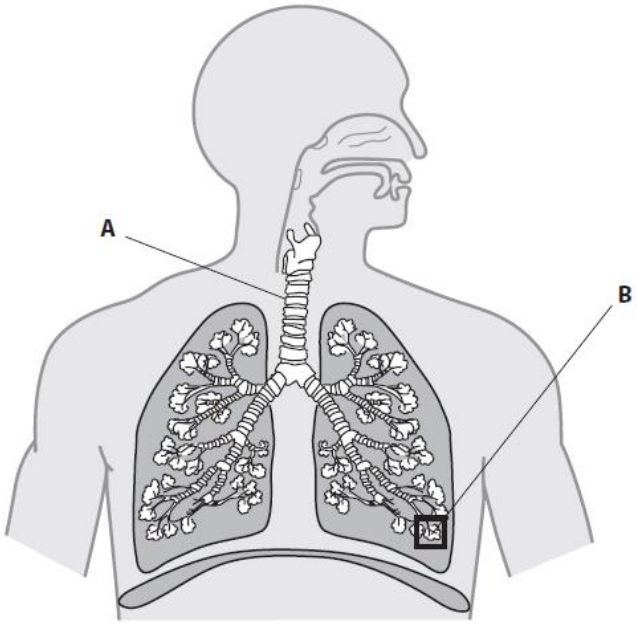
Theory Paper

Time Allowed: **1 hour**

Name: ……..

Biology Section

1. The diagram shows part of the human breathing system.



a. Name structures A and B.

A. .....

B. .....

(2)

b. Which gas passes into the blood from the air?

.....

(1)

c. What is this gas used for in the body?

.....

(1)

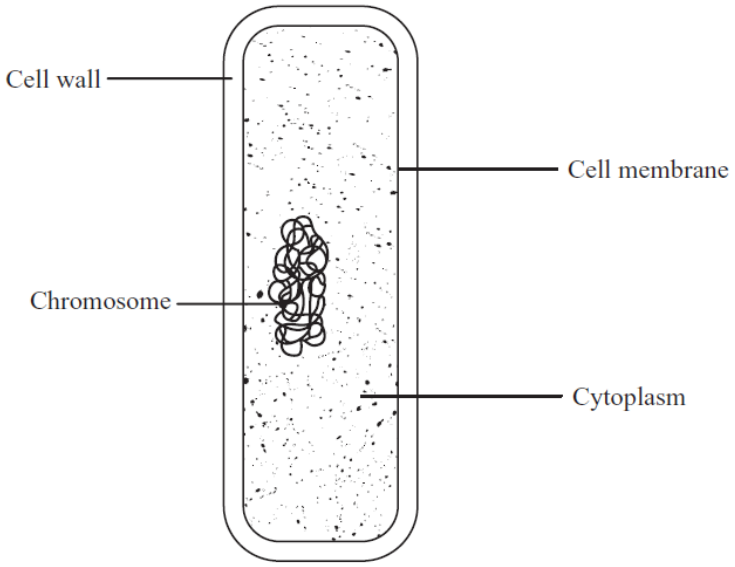
d. Which abundant gas diffuses into/out of the blood but is neither used nor produced by cells?

.....

(1)

[Total 5 marks]

2. Bacterial cells differ in structure from animal and plant cells. A typical bacterial cell is in the image below.



a. Give two similarities between the bacterial cell and a plant cell.

1. .....

.....

.....

2. .....

.....

.....

(2)

b. Give two differences between the bacterial cell and an animal cell

1. .....

.....

.....

2. .....

.....

.....

(2)

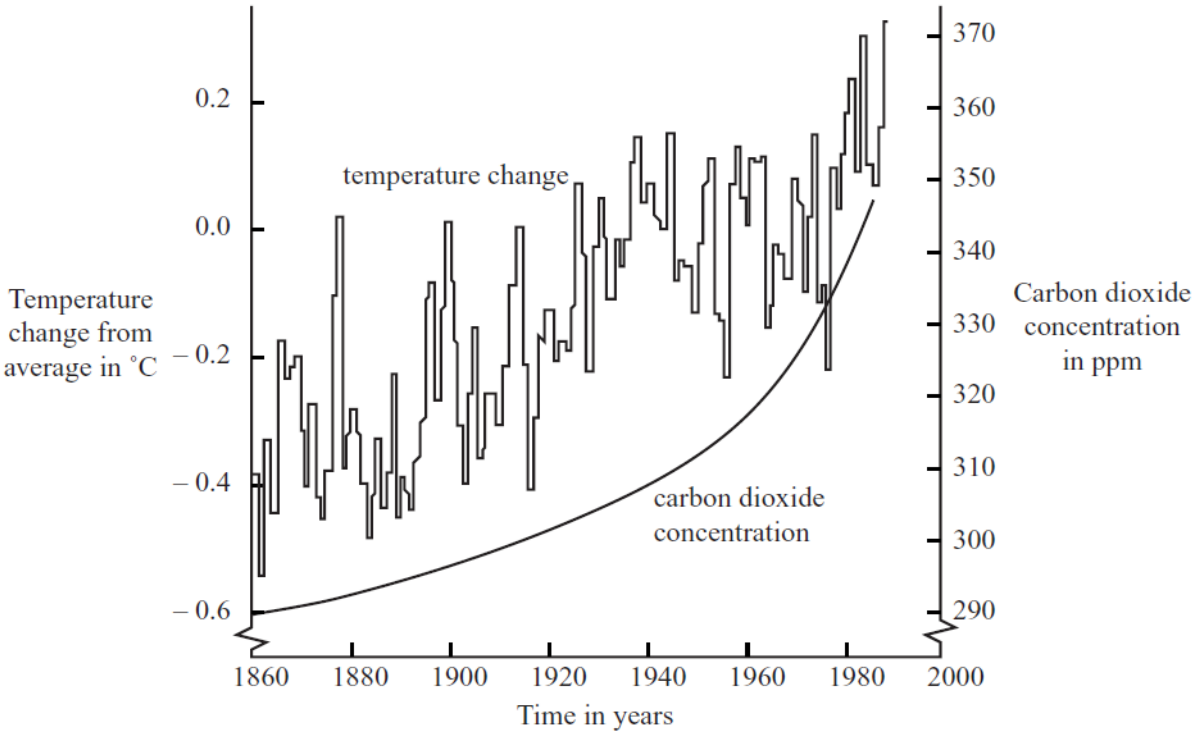
c. Bacterial cell walls are made of a substance called murein which is a conjugated protein (made of carbohydrate and a protein). What are plant cell walls made of?

.....

(1)

[Total 5 marks]

3. The graph shows time in years against CO_2 concentration and average temperature change.



a. From your general knowledge, what is the common name of the effect that CO_2 may be having on global temperatures?

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(1)

b. Describe the trend that CO_2 concentration seems to be having on global temperature.

.....

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(2)

c. Give one piece of evidence from the graph which suggests CO_2 concentration may not be affecting temperature.

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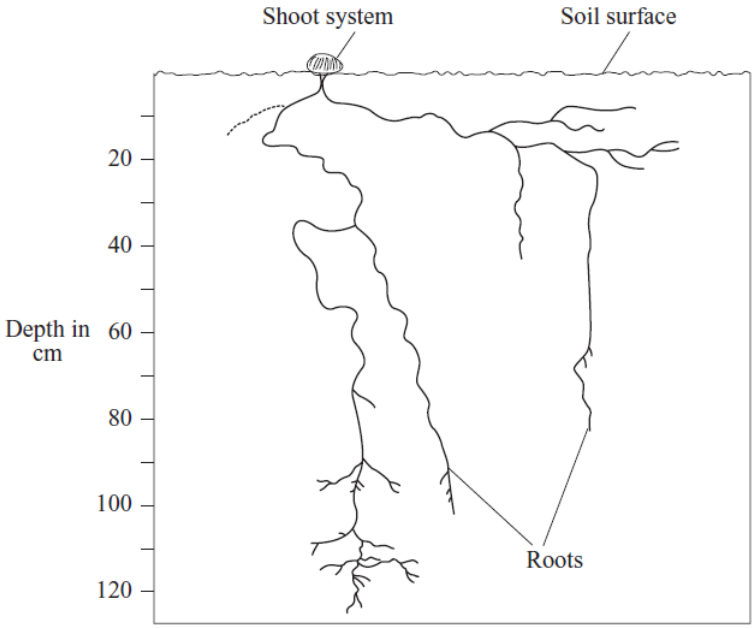
(1)

[Total 4 marks]

4. *FredobiaI* is a xerophyte (a plant that is adapted to dry conditions). The image below shows what *FredobiaI* looks like above and below the ground.



a. Give three adaptations that *Fredobia* shows to living in xerophytic (dry) conditions.

1. .....

.....

.....

2. .....

.....

.....

3. .....

.....

.....

(3)

b. Typically, xerophytic plants are found in deserts because water is in short supply. Name or describe two other places where plants would show xerophytic adaptations other than where the average temperate is high.

1. .....

.....

2. .....

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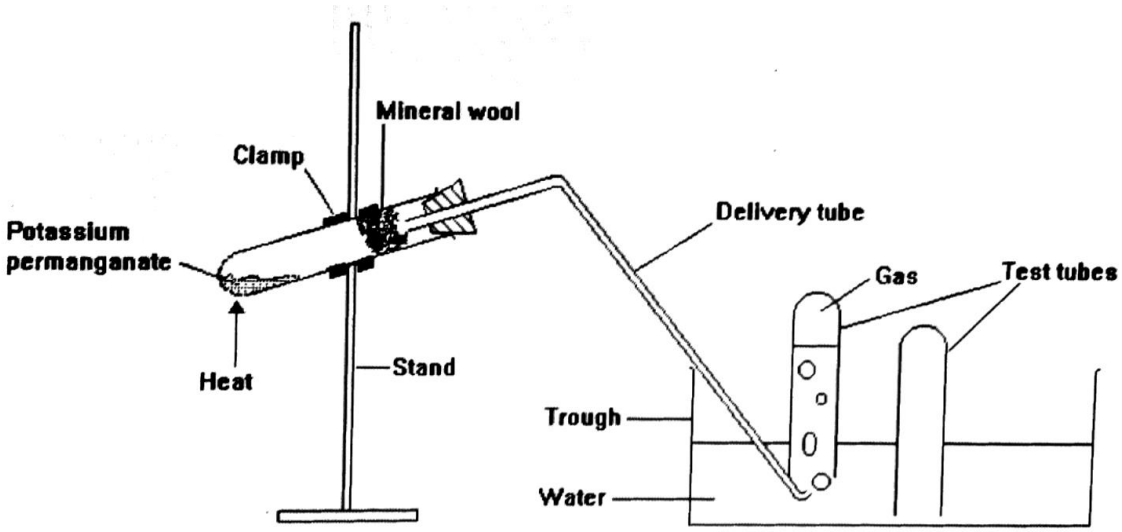
(2)

[Total 5 marks]

Chemistry Section

5. Potassium permanganate has the formula $KMnO_4$. If it is heated (as shown below) oxygen gas is evolved.



A simplified word and chemical equation for this reaction is shown below:

Potassium Permanganate → Potassium Manganate + Manganese Dioxide + Oxygen

..... $KMnO_4$ → ….... K_2MnO_4 + ….... MnO_2 + ... O_2

a. Balance the chemical equation above.

(1)

b. What type of chemical reaction is taking place?

.....

(1)

c. The pupil heated 1g of potassium permanganate but was disappointed to find that the first test tube of gas collected did not relight a glowing splint. Explain this observation.

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(2)

d. The teacher calculated the volume of oxygen that should be collected in this experiment. Despite making no experimental errors the pupil collected less oxygen gas than expected.
Explain why this is the case.

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(2)

[Total 6 marks]

6. In an experiment different metals were heated in a Bunsen burner flame for 30 seconds and then removed. The observations are given below.

Metal	Observation
Copper	Turned black - did not burn.
Magnesium	Burned with a bright white flame.
Silver	No obvious change.

a. Place the metals in order of reactivity starting with the most reactive.

Most Reactive: .....

.....

Least Reactive: .....

(2)

b. When metals burn in air, an oxidation reaction takes place.

i. What is meant by oxidation?

.....

.....

.....

(1)

ii. Write a word equation for the oxidation reaction that took place in the magnesium experiment.

(1)

c. In another experiment, a piece of polished copper was placed in a solution of silver nitrate.
What would you expect to be observed?

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(2)

d. In a third experiment, a piece of polished copper was placed in a solution of magnesium sulphate.
What would you expect to be observed?

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(2)

[Total 8 marks]

7. Metals change the colour of a flame when they are heated in it. Different metals give different colours to the flame, so flame tests can be used to identify the presence of a particular metal in a sample.

   Complete the table below giving electron configurations, flame colours or the metal ion in question: (The first row is done for you)

Ion	Electron Configuration	Flame colour
Na^+	2,8	Orange
K^+		
		Brick Red
Li^+		

(2)

[Total 6 marks]

Physics Section

8. This tennis ball machine can project a ball with a speed of 40 m/s every 4 seconds.

In all the questions ignore the effect of gravity and air resistance. Assume the balls travel in straight lines at constant speed between collisions.

a. How many balls does it project every minute?

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(1)

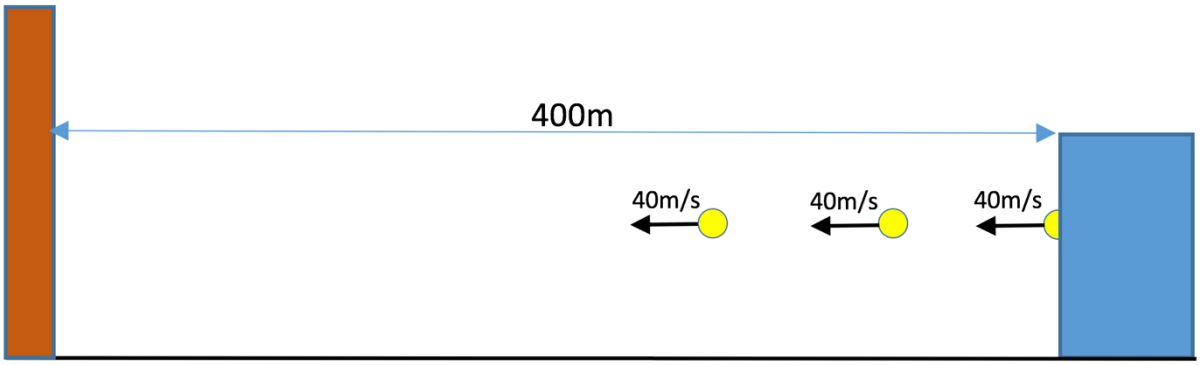
b. How far apart are the balls (how far has the first one travelled when the next one is projected)?

.....

.....

(1)

It fires the balls at a wall 400 m away.



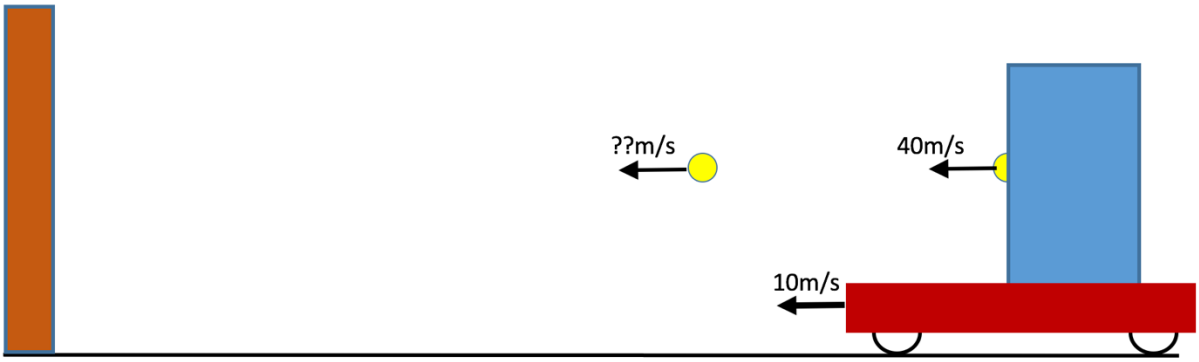
c. How long does it take for a ball to travel from the machine to the wall?

.....

.....

(1)

The machine is now mounted on a railway truck which moves at 10 m/s towards the wall.



The first ball is fired when the machine is 400m away.

d. How fast is the ball moving relative to the ground?

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(1)

The machine fires another ball 4 s later.

e. How far has the machine moved in that time?

.....

.....

(1)

f. How far does the second ball have to travel before it hits the wall?

.....

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(1)

g. How long does it take the second ball to reach the wall?

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.....

(1)

A third ball is fired 8 s after the first one.

h. How far has the machine moved in that time?

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(1)

i. How far does the third ball have to travel before it hits the wall?

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(1)

j. How long does it take the third ball to reach the wall?

.....

.....

(1)

Ball number	Time of firing (s)	Time of flight (s)	Time of arrival at the wall (s)	Time between balls hitting the wall (s)	Calculated time between balls hitting the wall (s)
1	0	8	8	n/a	n/a
2	4				
3	8				
4	12				

k. Complete the table of the times that the balls are fired and the time of arrival.

(2)

l. Complete the fifth column by finding the difference in the times of arrival at the wall.

(1)

The formula for the time (T) between balls hitting the wall is:

$$T = \left(\frac{V}{V + W} \right) T_0$$

Where: V = speed of the balls projected by the machine (in this case 40m/s)
W = speed of the truck along the track (in this case 10m/s)
T_0 = time between balls fired from the machine (in this case 4s)
T = time between balls hitting the wall

m. Use the formula to calculate the time between balls hitting the wall and complete the sixth column in the table.

(2)

[Total 14 marks]

9. This question is about what we call the Doppler effect. When a police car or ambulance moves past you will hear a change of pitch in the note of the siren. You can hear the same effect with Formula One cars and motorbikes.

   a. From your own experience, how does the pitch change from when the vehicle with the siren changes from approaching you to going away from you?

   .....

   .....

   (1)

This is similar to the effect in question 1 where the frequency of the balls arrival increases when the source is moving towards you. The frequency decreases if the source is moving away from you. You can hear the effect with sound and there is a similar effect with light.

The frequency of light is related to its colour:

Blue	**high frequency**
Green	**medium frequency**
Red	**low frequency**

If a source is moving towards the observer, then the frequency is increased i.e. it is Blue-shifted.

If the source is moving away from the observer, then the frequency is decreased i.e. it is Red-shifted.

Galaxies, like our own Milky Way, rotate. In the picture below the stars on the left hand side of the galaxy are coming towards us and the ones on the right are going away

b. In which way is the light affected by the motion of the stars:

i. On the left .....

ii. On the right .....

(1)

The stars orbit in a galaxy like the planets orbit the Sun. Instead of a star at the centre there is a supermassive black hole. The orbital velocity is the speed at which the stars go round the centre. It typically takes 200 million years for a star to go once round in the galaxy and the orbital velocity will be hundreds of kilometres per second.

We can calculate the orbital velocity of a star from the change in frequency Δf.

$$v = \left(\frac{\Delta f}{f} \right) c$$

Where: v = orbital velocity

Δf = the change in frequency
f = original frequency
c = speed of light = 300,000km/s

For a particular star in a galaxy we find that for light with frequency f = 500THz the change in frequency Δf = 0.4THz. THz means Tera-Hertz, a million million cycles per second, but you do not need to know that! You may have met a Tera-Byte hard drive.

c. Use the formula to calculate the orbital velocity of the star.

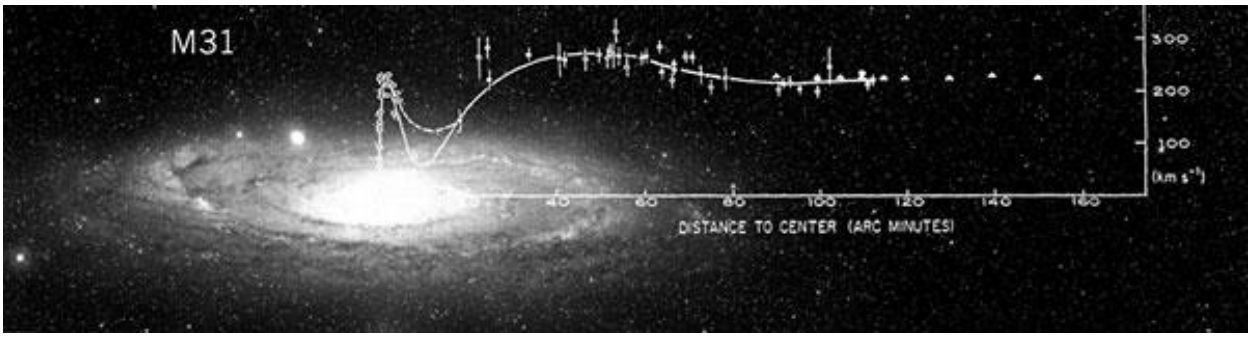
.....

.....km/s

(1)

When data is collected for many stars in a galaxy at different distances from the centre we find that the observed results differ considerably from what is predicted.

This is the data for the Andromeda galaxy which shows how the orbital velocity stays more or less constant at large distances from the centre:



The graph below shows the predicted variation of orbital velocity with distance form the centre of the galaxy.

d. Why do you think the predicted curve decreases so much, as you move further and further away from the centre of the galaxy? What might cause the observed values to be so much higher?

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(3)

[Total 6 marks]