Q1.

The cell membrane is important in the control of which substances can enter and leave the cell.

(a) The cell membrane consists of a phospholipid bilayer.

(i) Why do phospholipids form a bilayer?

(1)

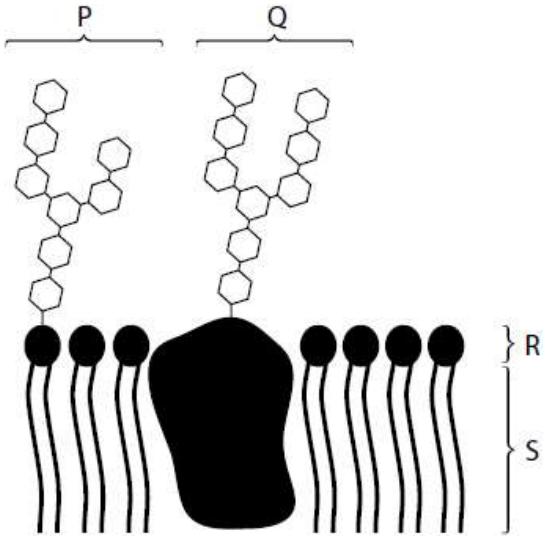
☐ **A** the hydrophobic heads dissolve in the aqueous (water) environment

☐ **B** the hydrophobic heads move away from the aqueous (water) environment

☐ **C** the hydrophobic tails dissolve in the aqueous (water) environment

☐ **D** the hydrophobic tails move away from the aqueous (water) environment

(ii) This diagram shows part of a cell membrane.



Which letter represents a membrane glycoprotein?

(1)

☐ **A** P

☐ **B** Q

☐ **C** R

☐ **D** S

(b) State what is meant by the term **osmosis.**

(1)

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(c) Compare and contrast exocytosis and endocytosis.

(3)

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(d) Explain why oxygen molecules can pass directly through the cell membrane.

(3)

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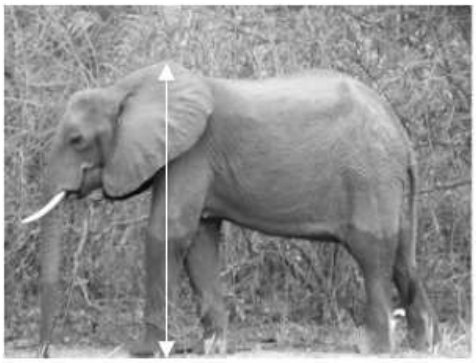
(Total for question = 9 marks)

Q2.

The photographs show two mammals, an elephant and a mouse.



Magnification ×0.02

(a) The height of a mouse is 3 cm.

Calculate how many times taller an elephant is than a mouse.

Use the white line drawn on the photograph of the elephant to calculate this value.

(2)

Answer .....

(b) The respiratory system of an elephant is different from that of other mammals.

The lungs are attached to the chest cavity wall and diaphragm by collagen fibres.

Describe how the lungs of an elephant are adapted for gas exchange.

(3)

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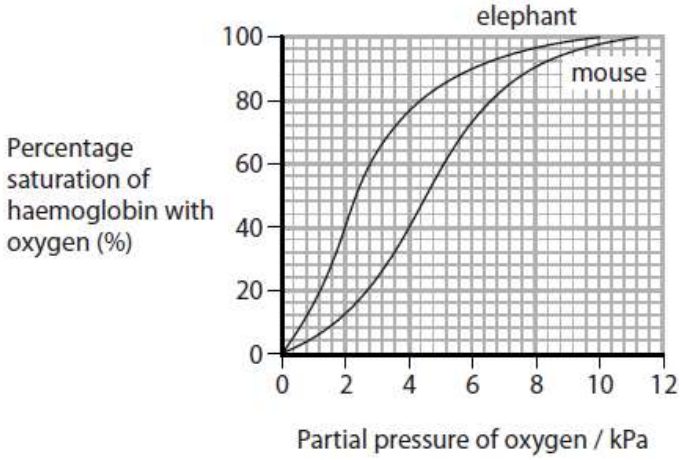
* (c) Graph 1 shows the oxygen dissociation curve of haemoglobin for a mouse and for an elephant.

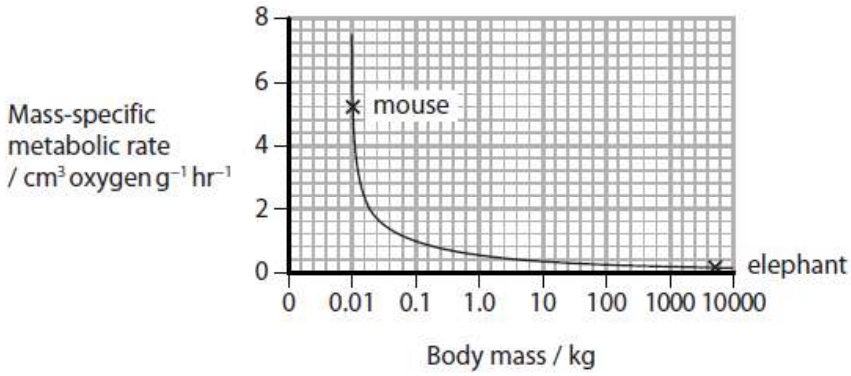
Graph 1



Graph 2 shows the mass-specific metabolic rate for a mouse and for an elephant.

Mass-specific metabolic rate is a measure of how much oxygen is needed for chemical reactions per gram of body tissue.

Graph 2



Explain the difference in the oxygen dissociation curves of haemoglobin for a mouse and for an elephant.

Use the information in both graphs to support your answer.

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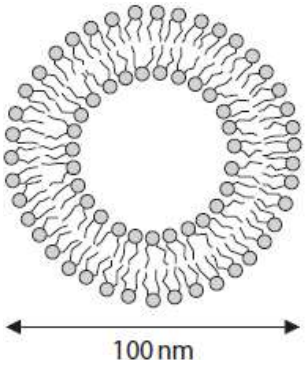
(Total for question = 11 marks)

Q3.

Liposomes are spherical structures composed of phospholipids. They can be made by adding phospholipids to water.

Liposomes can be used to study membrane permeability.

(a) The diagram shows a liposome.



(i) Calculate the volume of this liposome, using the formula

$$V = \frac{4}{3}\pi r^3$$

(2)

Answer .....

(ii) Explain the arrangement of phospholipids in liposomes.

(2)

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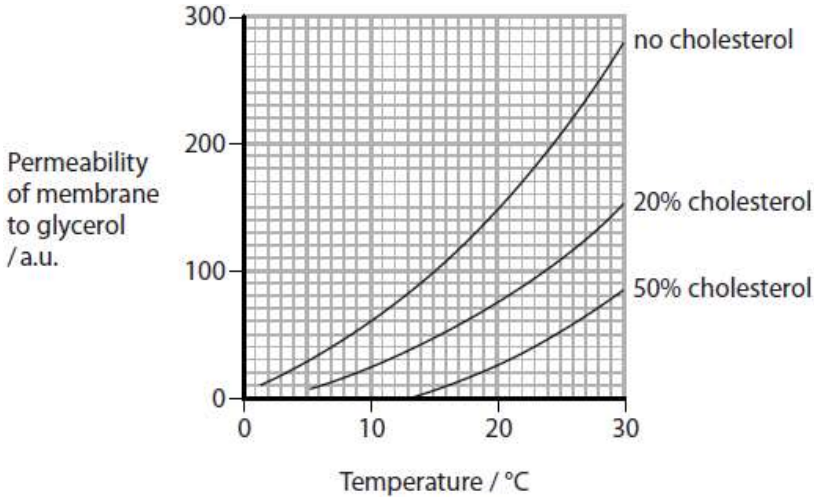
(b) The presence of cholesterol in the membrane affects membrane permeability.

A student investigated the effect of cholesterol on the permeability of liposomes to glycerol at different temperatures.

Liposomes were made by replacing 20% and 50% of the phospholipid with cholesterol.

Liposomes without cholesterol were also made.

The graph shows the results of this investigation.



(i) How does glycerol pass through the liposome membrane?

(1)

☐ **A** active transport

☐ **B** diffusion

☐ **C** endocytosis

☐ **D** osmosis

(ii) Describe the effects of cholesterol and temperature on membrane permeability, as shown in the graph.

(3)

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(iii) Explain why cholesterol and temperature affect membrane permeability.

(2)

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(Total for question = 10 marks)

Q4.

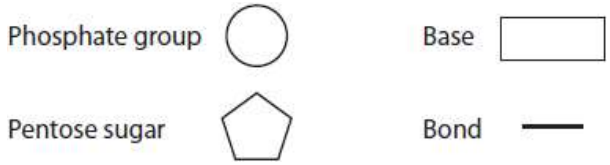
Nucleic acids include DNA and RNA.

(a) Each single strand of a DNA molecule is synthesised from mononucleotides.

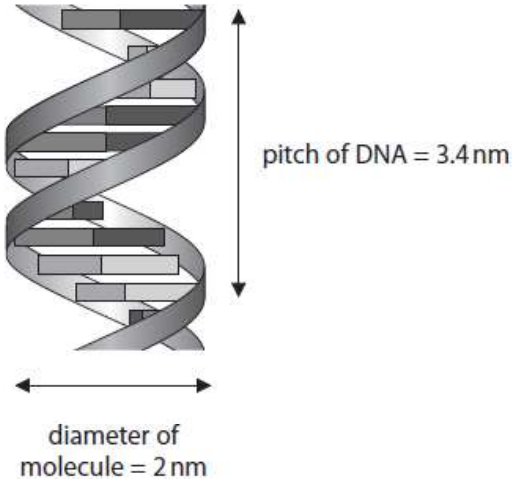
Draw a diagram to show two mononucleotides joined together in a single strand of DNA.

Use the symbols shown for each component in your diagram.

(3)



(b) The diagram represents part of a DNA molecule.



The pitch is the length of one complete turn in the double helix.
There are 10 base pairs in one pitch.

(i) Calculate the distance between one base and the next base on one strand of DNA.

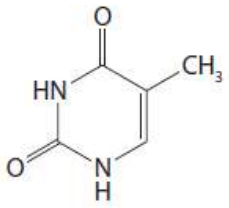
Give your answer to an appropriate number of significant figures.

(1)

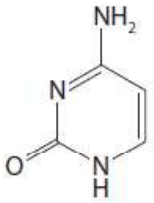
Answer ..... nm

(ii) The diagram shows the structure of thymine and four other bases, **P**, **Q**, **R** and **S**.

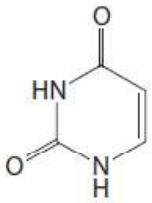
Bases **P** and **S** can form three hydrogen bonds each and bases **Q** and **R** can form two hydrogen bonds each.



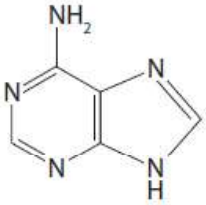
thymine



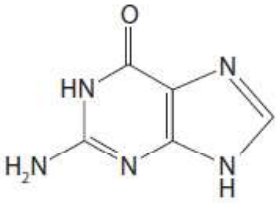
base **P**



base **Q**



base **R**



base **S**

Explain which of the four bases **P**, **Q**, **R** or **S** is adenine.

(2)

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(c) Compare and contrast the structure of messenger RNA (mRNA) with the structure of transfer RNA (tRNA).

(4)

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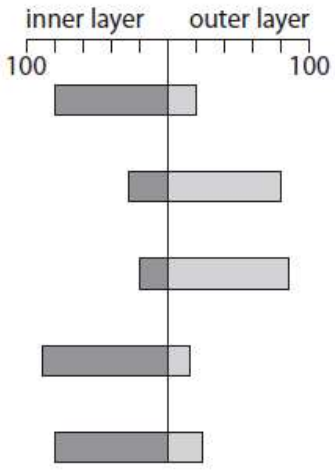
(Total for question = 10 marks)

Q5.

Platelets are involved in the blood clotting process.

(a) The table shows the phospholipid content of the membranes of platelets.

Phospholipid	Percentage of total membrane phospholipids (%)	Percentage distribution of phospholipids in the membrane (%)
phosphatidylethanolamine	30	
phosphatidylcholine	27	
sphingomyelin	23	
phosphatidylserine	15	
other types	5	

When platelets trigger the blood clotting process, more phosphatidylserine molecules move into the outer layer of the membrane.

(i) Estimate the ratio of phosphatidylserine in the inner layer to that in the outer layer before the blood clotting process is triggered.

(1)

Answer .....

(ii) Describe the effect that the movement of phosphatidylserine into the outer layer will have on the content of phospholipids in the membranes of platelets.

(2)

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(iii) Describe how the movement of phosphatidylserine into the outer layer results in the production of thrombin in the blood clotting process.

(4)

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Explain why thrombin inhibitors affect the time taken for blood to clot.

(b) Thrombin inhibitors are drugs that have an effect on the time taken for blood to clot.

(4)

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(Total for question = 11 marks)

Q6.

(a) Explain how human lungs are adapted for rapid gas exchange.

(3)

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(b) Cystic fibrosis is an inherited condition which reduces gas exchange.

The most frequently observed CFTR allele associated with cystic fibrosis carries the ΔF508 mutation.

(i) State what is meant by the term **allele**.

(1)

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(ii) The CFTR protein coded for by this mutation has one missing amino acid compared to the functioning protein.

Explain how this mutation results in a non-functioning CFTR protein.

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(4)

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(iii) Explain why people with cystic fibrosis may develop lung infections.

(4)

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(Total for question = 12 marks)

Q7.

Red-green colour blindness is a common trait in humans.

(a) The gene for red-green colour blindness is located on the X chromosome.

State what is meant by the term **gene**.

(1)

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(b) Describe how the two strands of DNA forming the double helix in a gene are held together.

(2)

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(c) Explain why each codon for the DNA genetic code must contain at least three bases.

(3)

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(d) A red-green colour blind father and an unaffected heterozygous mother had a child.

Determine the probability of this child being red-green colour blind.

Use a genetic diagram to support your answer.

(3)

Probability .....

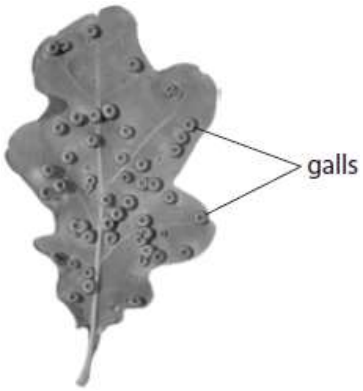
(Total for question = 9 marks)

Q8.

Some insects lay eggs inside leaves. This causes the leaves to produce swellings called galls.

The galls supply the developing insects with nutrients and protect them from the external environment.

The photograph shows galls on a leaf.



In an investigation, the concentrations of protein molecules and amino acids found in healthy leaves, leaves with galls and in the galls themselves were determined.

(a) The insects were removed from each gall before the investigation.

Suggest why the insects were removed from the galls.

(2)

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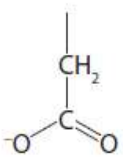
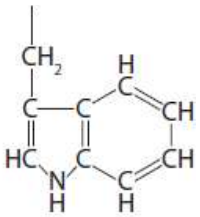
(b) The amino acids were extracted and dissolved in a non-polar organic solvent.

(i) The diagram shows the R group of the amino acids, alanine, aspartate and tryptophan.

alanine



aspartate



tryptophan

Which row of the table describes the solubility of these amino acids in a non-polar organic solvent?

(1)

	Solubility in a non-polar organic solvent Most soluble → Least soluble		
☐ **A**	alanine	aspartate	tryptophan
☐ **B**	alanine	tryptophan	aspartate
☐ **C**	aspartate	alanine	tryptophan
☐ **D**	aspartate	tryptophan	alanine

(ii) The solubility of an amino acid can be determined by measuring the maximum mass of the amino acid that dissolves in a known volume of solvent.

The solubility of the amino acid histidine in a solvent is 43.5 g dm^{-3}.

The mass of the amino acid leucine that dissolves in 250 cm^3 of the same solvent is 5.5 g.

Calculate how many times more soluble histidine is than leucine.

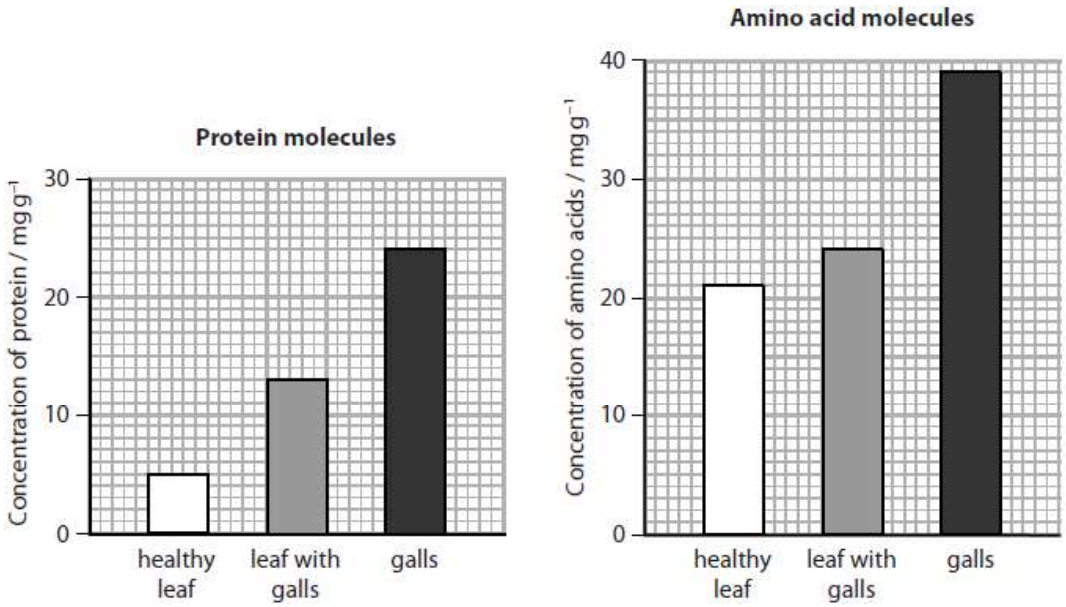
(2)

Answer .....

* (c) The gall-forming insects secrete saliva into the plant tissues.

The saliva contains enzymes that change the nutrients in the leaf and cause the galls to form.

The graphs show the concentrations of protein molecules and amino acid molecules in tissues from a healthy leaf, tissues from a leaf with galls and in the galls themselves.



The table shows the abundance of five amino acid molecules.

Amino acid	Abundance in tissues of a healthy leaf	Abundance in tissues of a leaf with galls	Abundance in galls
alanine	++	+	++
arginine	++	–	++
histidine	–	–	++
leucine	+	+	+
tryptophan	–	–	–

Key

++ most abundant

– absent

Explain the results of this investigation. Use the information in both graphs and the table to support your answer.

(6)

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(Total for question = 11 marks)

Q9.

Collagen is an insoluble, fibrous protein.

(a) Describe the roles of RNA in the synthesis of collagen.

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(b) Explain how the primary structure of collagen determines its properties.

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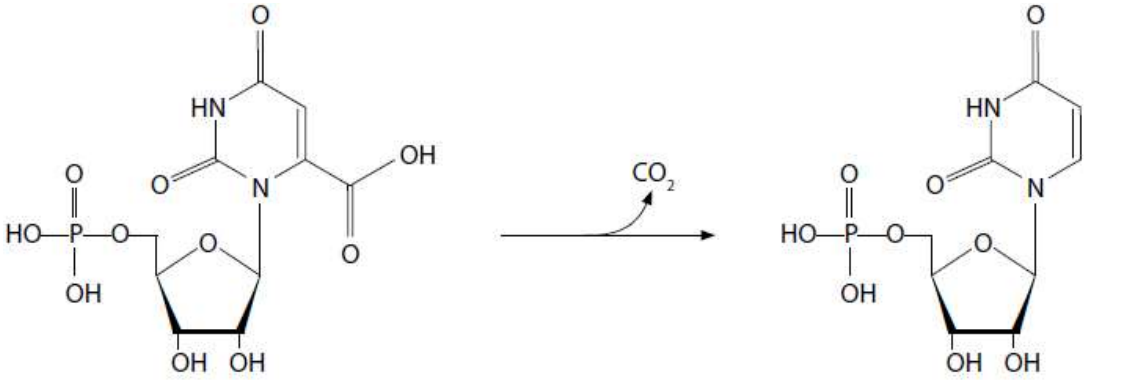
(Total for question = 9 marks)

Q10.

The enzyme OMP decarboxylase is involved in the synthesis of the mononucleotide uridine monophosphate.

(a) The diagram shows the reaction catalysed by OMP decarboxylase.



(i) Which sugar is present in uridine monophosphate?

(1)

☐ **A** deoxyribose

☐ **B** galactose

☐ **C** glucose

☐ **D** ribose

(ii) Draw a circle around the base in uridine monophosphate.

(1)

(iii) Suggest one way in which cells use uridine monophosphate.

(1)

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(b) The enzyme OMP decarboxylase increases the rate of carbon dioxide removal from orotidine monophosphate by 10^{17} times.

(i) State how OMP decarboxylase increases the rate of this reaction.

(2)

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(ii) Explain why OMP decarboxylase catalyses this reaction only.

(3)

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(Total for question = 8 marks)