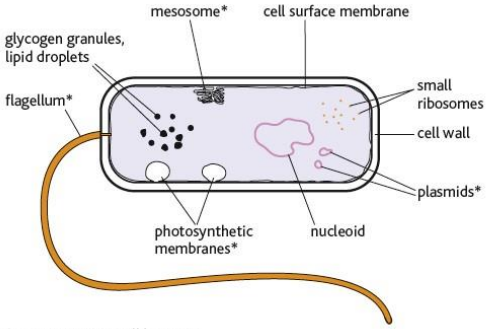
Threshold Concept	Description	Task title	**Mastery level (RAG)**	Date
1	**Biology: Cell structure and function**	Eukaryotic and prokaryotic cell structure Calculating magnification		
2	**Biology: Cell specialisation**	Structure and function of specialise cells: • palisade mesophyll cells in a leaf • sperm cells • root hair cells in plants • white blood cells • red blood cells.		
3	**Chemistry: Structure and bonding**	Structure of an atom Bonding: • ionic • covalent • metallic Calculation of relative formula mass Physical properties of metals		
4	**Reactions**	Reactions of metals with oxygen, water and dilute acid The reactivity series		
5	**Waves**	Features common to all waves Transverse and longitudinal waves Calculation of wave speed ($v = f \lambda$)		
4	**Use of electromagnetic waves**	Uses of electromagnetic waves in communications		

1. Summary sheet 1: Cell structure

Prokaryotes are single celled organisms, including bacteria. They are simpler and smaller than Eukaryotic cells.

Bacterial cells have:

- no nucleus with circular DNA free in the cytoplasm
- cell wall made from peptidoglycan
- no membrane-bound organelles
- small ribosomes.

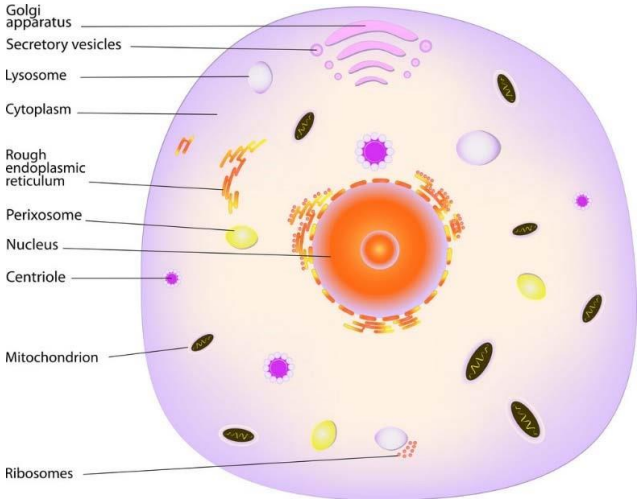


* = not present in all bacteria

Eukaryotic cells include animal and plant cells. They are larger and more complex than prokaryotic cells.

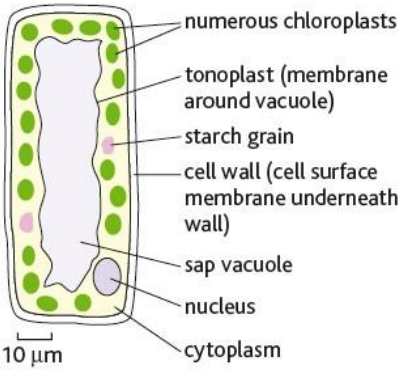
Animal cells have:

- linear DNA contained inside a nucleus
- no cell wall
- larger ribosomes and many membrane-bound organelles including mitochondria where aerobic respiration occurs and endoplasmic reticulum and golgi which are involved in the processing of proteins.

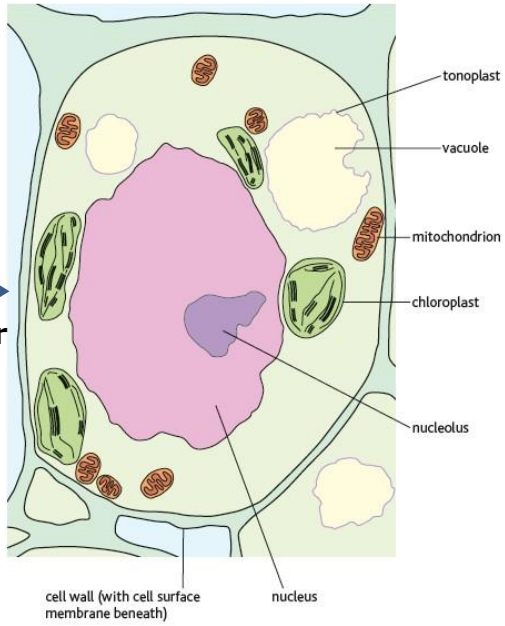


Plant cells have the same organelles as animal
cells but they also have:

- a cell wall
- a large vacuole containing cell sap
- chloroplasts for photosynthesis.



greater detail



Summary sheet 3: Microscopy

Magnification is how much bigger the image is than the specimen on the microscope slide.

The size of the specimen can be calculated using the formula:

$$\text{length of the specimen} = \frac{\text{length of the image}}{\text{magnification}}$$

With a light microscope the magnification is the combination of the magnification of the objective lens and the eye piece lens.

For example a 40× objective lens and a 10× eye piece lens produce a total magnification of 400×.

When you are doing magnification calculations you must have all the lengths in the same units.

1 cm	10 mm
1 mm	1000 µm
1 µm	1000 nm

Calculation

Calculate the actual size of a cell with a diameter of 8 mm using 100× magnification.

$$\text{Actual size} = \frac{8}{100} = 0.08 \text{ mm}$$

$$= 80 \text{ µm}$$

Resolution is a measure of how easy it is to distinguish between two points that are close together i.e. how much detail can be distinguished. Electron microscopes have a better resolution than light microscopes so they can see more detail.

Worksheet 1: Cell structures 1

Extracting key information from text is an important study skill for BTEC candidates.

Read through the passage below about animal, plant and bacterial cells. Use the information and your own knowledge to complete the table to list some of the structural features of animal, plant and bacterial cells.

The plant cell and the animal cell possess a nucleus containing chromosomes and a nucleolus. In a bacterial cell the DNA is located in the cytoplasm. Only the bacterial cell and the plant cell have a cell wall but all three cells have a cell membrane. The plant cell wall is made of cellulose and the bacterial cell wall is made of peptidoglycan.

Centrioles are present only in the animal cell and chloroplasts are found only in the plant cell. Mitochondria and rough endoplasmic reticulum are not present in the bacterial cell. All three cells contain structures called ribosomes which are involved in the synthesis of protein. Bacterial cells can have pili or a capsule.

Features present in animal cells	Features present in plant cells	Features present in bacterial cells

Worksheet 2: Cell structures 2

Extracting key information from text is an important study skill for BTEC candidates.

Read through the passage below about animal, plant and bacterial cells. Use the information and your own knowledge to draw and label an animal, plant and bacterial cell. You should include the features listed if appropriate.

The plant cell and the animal cell possess a nucleus containing chromosomes and a nucleolus. In a bacterial cell the DNA is located in the cytoplasm. Only the bacterial cell and the plant cell have a cell wall but all three cells have a cell membrane. The plant cell wall is made of cellulose and the bacterial cell wall is made of peptidoglycan.

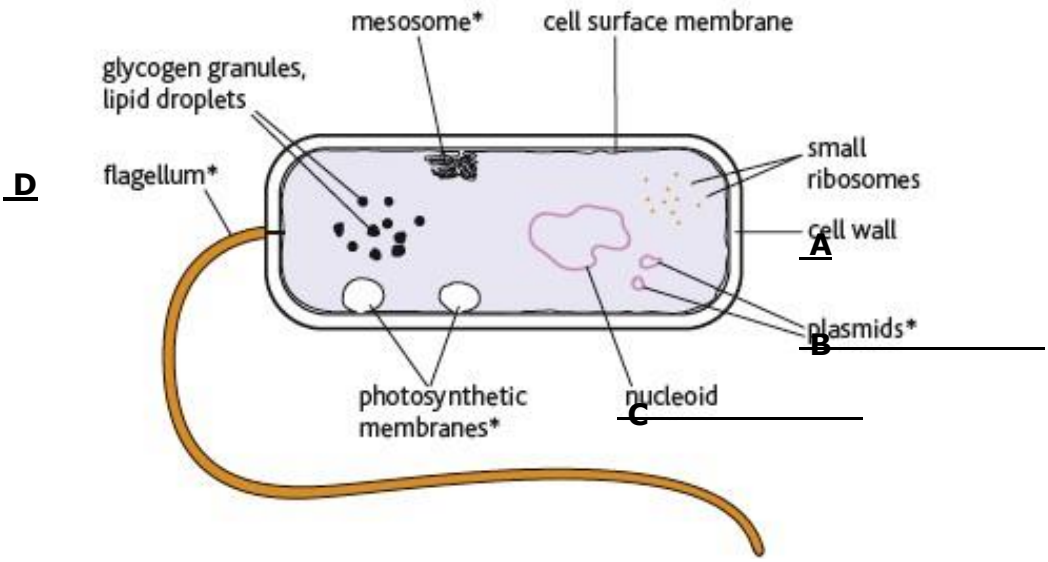
Centrioles are present only in the animal cell and chloroplasts are found only in the plant cell. Mitochondria and rough endoplasmic reticulum are not present in the bacterial cell. All three cells contain structures called ribosomes which are involved in the synthesis of protein. Bacterial cells can have pili or a capsule.

cell wall nucleus cell membrane ribosome capsule mitochondria cytoplasm chloroplast plasmid chromosome

Animal cell	**Plant cell**
Bacterial cell	

Practice questions

1 The diagram shows a bacterial cell with some of the key features labelled.



a Label cell features A, B, C and D.

b Complete the table to identify three features present in animal cells and describe their function.

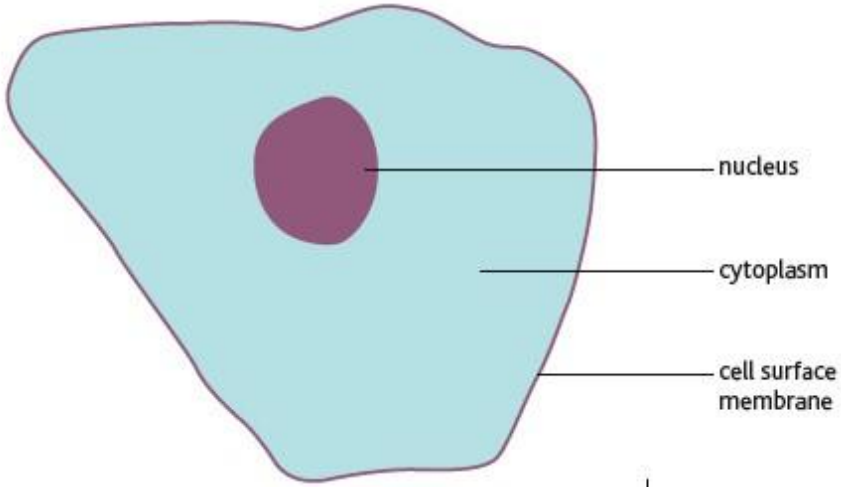
Animal cell feature	Function

c Some antibiotics prevent protein synthesis by targeting the ribosome.

Ribosomes in eukaryotes have a different structure to prokaryotes.

In no more than 50 words, explain why these types of antibiotics can be used to treat bacterial infections without effecting human cells.

2 The diagram shows an animal cell with three key features labelled.



a Identify three additional features which are found in animal cells and describe their functions.

1

2

3

b An image of an animal cell nucleus with a diameter of 6 µm was obtained using a 10× eye piece lens and 20× objective lens. Calculate the diameter of the nucleus on the image.

.

2. Specialised cells

Eukaryotic cells can become specialised to have particular roles. It is important to recognise the unique features that particular cells have and link these to the function of the cell.

For each specialised cell include: • At least one drawing • The function of the cell • Details of how each cell is adapted so that it can carry out its function There are BBC Bitesize links but you may also find information in your GCSE revision guide or online.
Red blood cells https://www.bbc.co.uk/bitesize/guides/zqnsrwx/revision/6
White blood cells https://www.bbc.co.uk/bitesize/guides/zxr7ng8/revision/9
Sperm cell https://www.bbc.co.uk/bitesize/guides/zpqpqhv/revision/12
Palisade mesophyll cells in a leaf https://www.bbc.co.uk/bitesize/guides/zyk8msg/revision/2
Root hair cells in plants https://www.bbc.co.uk/bitesize/guides/zpqpqhv/revision/12

3. Chemistry: Structure and bonding

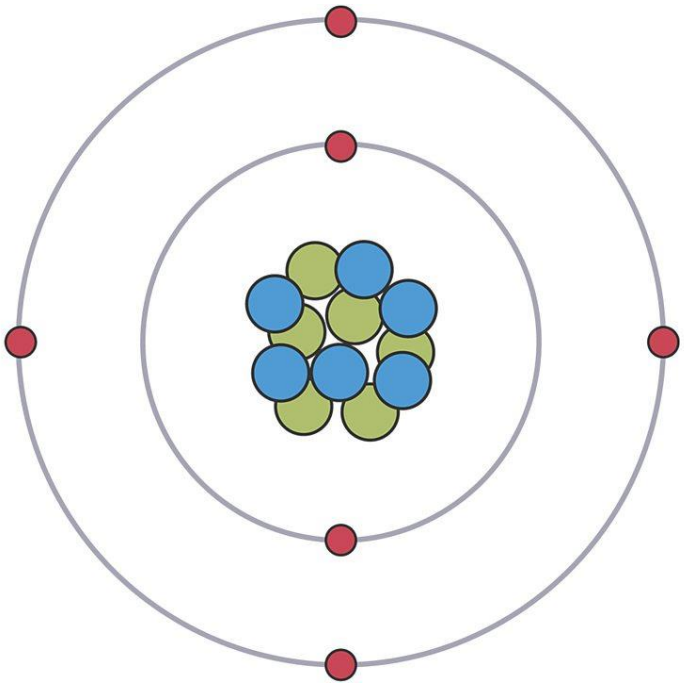
Subatomic particles: nucleus (protons and neutrons), electrons in shells.

Describe the particles in terms of their relative masses and relative charges:

- Protons – mass 1, charge +1.
- Electrons – mass = negligible ($\frac{1}{1840}$), charge −1.
- Neutrons – mass = 1, charge = 0.

Notes

- Number of protons = number of electrons (uncharged/neutral atoms).
- Proton number = atomic number.
- Mass number = protons + neutrons.



Formation of ions

Atoms of metallic elements in Groups 1,2 and 3 can form positive ions when they take part in reactions since they are readily able to lose electrons.

Atoms of Group 1 metals lose one electron and form ions with a 1+ charge, e.g. Na^{+}

Atoms of Group 2 metals lose two electrons and form ions with a 2+ charge, e.g. Mg^{2+}

Atoms of Group 3 metals lose three electrons and form ions with a 3+ charge, e.g. Al^{3+}

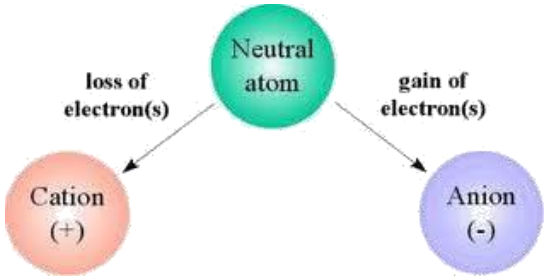
Atoms of non-metallic elements in Groups 5, 6 and 7 can form negative ions when they take part in reactions since they are able to gain electrons.

Atoms of Group 5 non-metals gain three electrons and form ions with a 3– charge, e.g. N^{3-}

Atoms of Group 6 non-metals gain two electrons and form ions with a 2– charge, e.g. O^{2-}

Atoms of Group 7 non-metals gain one electrons and form ions with a 1– charge, e.g. Cl^{-}

A**N**ions = **N**egative Ca**+**ions = **+**ive



Why are ions negative or positive?

- Find the atomic number (the smaller number with the symbol).
- This equals the number of protons, which equals the number of electrons in an uncharged/neutral atom.
- If electrons are lost from the atom, there are now more protons than electrons, so the ion is positively charged.
- If electrons are gained by the atom, there are now fewer protons than electrons, so the ion is negatively charged.

Electron configuration

Filling electron shells

- n = 1, maximum = $2e^-$ ● n = 2; maximum = $8e^-$
- n = 3 ;maximum = $18e^-$
- n = 4; maximum = $32e^-$

Representing electron configurations

- Write as e.g. 2.8.3 or 2,8,3

Using the Periodic Table

- Period number (row) = number of shells
- Group number (column) = number of electrons in the outer (last) shell

Group number	**1**		**2**		**3**				**5**		**6**		**7**	
	Li		**Be**		**B**				**N**		**O**		**F**	
	Atom	Ion	Atom	Ion	Atom	Ion			Atom	Ion	Atom	Ion	Atom	Ion
Electrons	−3	−2	−4	−2	−5	−2			−7	−10	−8	−10	−9	−10
Protons	+3	+3	+4	+4	+5	+5			+7	+7	+8	+8	+9	+9
Overall charge	0	1+	0	2+	0	3+			0	3−	0	2−	0	1−
Electron configuration	2.1	2	2.2	2	2.3	2			2.5	2.8	2.6	2.8	2.7	2.8
Name of ions	lithium		beryllium		boron				nitride		oxide		fluoride	
	Lose electrons, charge = +group number								Gain electrons, charge = group number − 8					

Hints and tips

Always ...

... count the electrons!

... remember that ions should have full outer shells.

... make sure that when an ion is formed, you put square brackets round the diagram and show the charge.

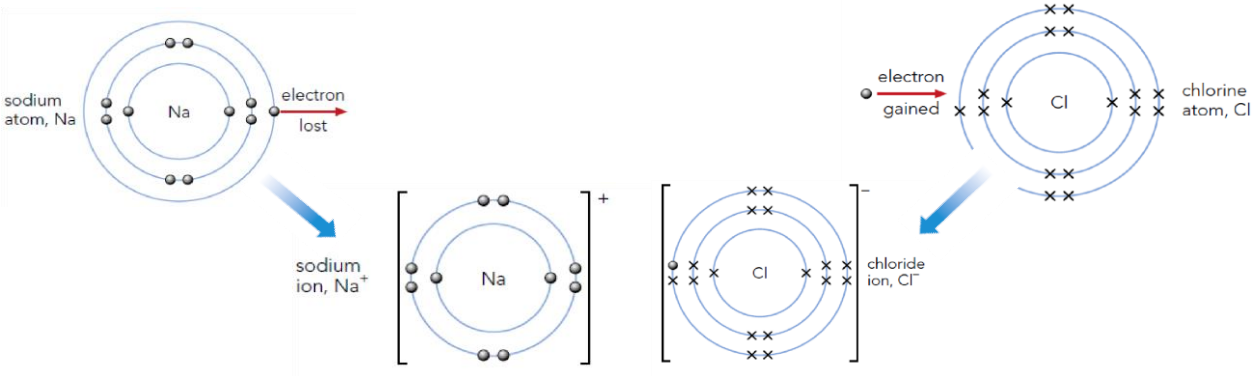
Never ...

... show the electron shells overlapping.

... show electrons being shared (ions are formed by the **transfer** of electrons!).

... remove electrons from the inner shell.

... give metals a negative charge.



KS4 – Covalent compounds (simple covalent bonding)

A covalent bond is form when a pair of electrons is shared between two atoms.

Covalent bonding results in the formation of molecules.

Hints and tips

Always …

… show the shells touching or overlapping where the covalent bond is formed.

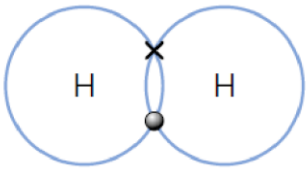
… count the final number of electrons around each atom to make sure that the outer shell is full.

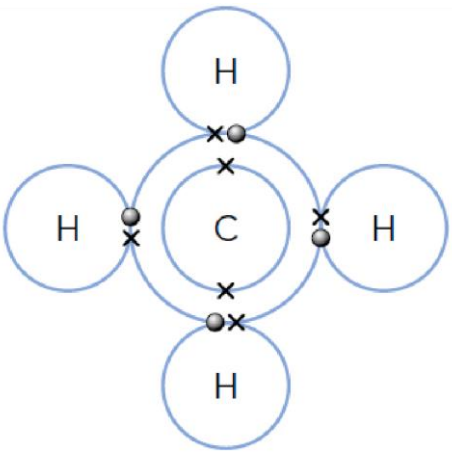
Never …

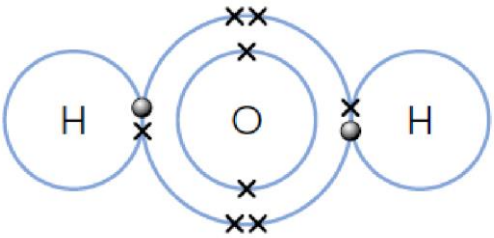
… include a charge on the atoms.

… draw the electron shells separated.

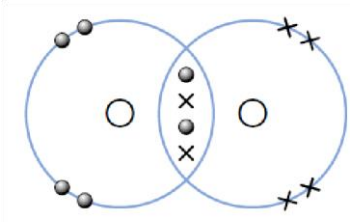
… draw unpaired electrons in the region of overlap

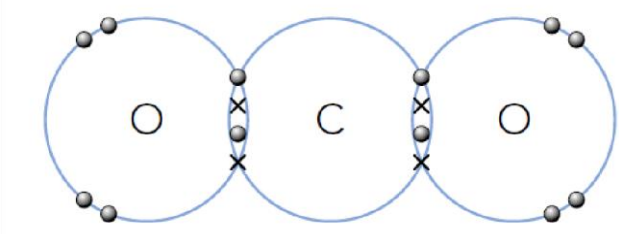






The two diagrams here only show the outer-shell





KS4 – Metals and metallic bonding

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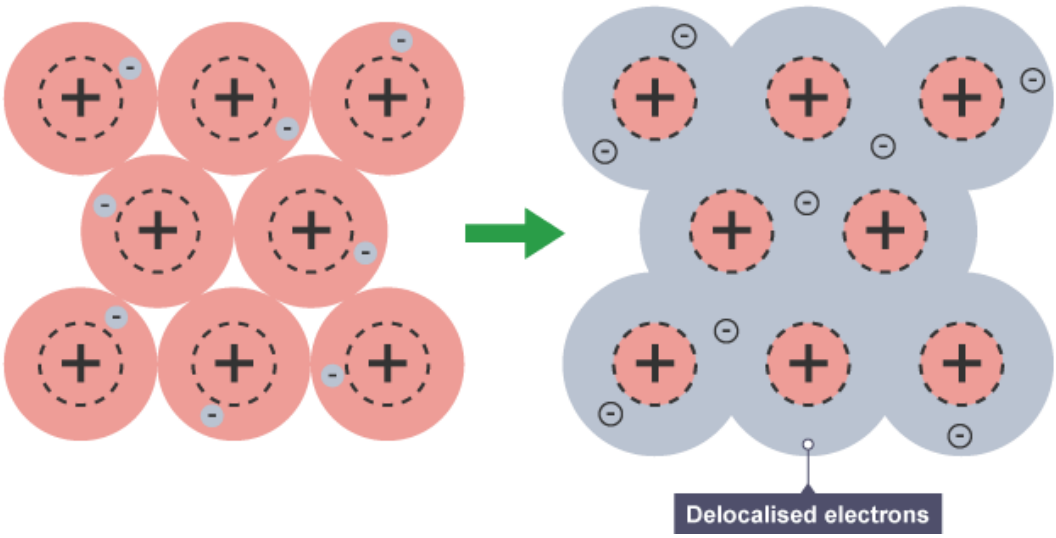
Description of metallic bonding 
Properties of metals
Alloys

Worksheet 1: Atomic structure and the Periodic Table

Complete the following sentences and definitions to give a summary of this topic.

Structure of an atom

The nucleus contains ...

_____

The electrons are found in the ...

_____

To work out the number of each sub-atomic particle in an atom we use the Periodic Table (PT). The number of protons is given by ...

_____

In a neutral atom the number of electrons is ...

_____

To work out the number of neutrons we ...

_____

Structure of an ion

When an atom becomes an ion, only the number of _____ changes.

Calamine lotion is used to treat itching. The main ingredients are two metal oxides.

(a) One of the metal oxides has a relative formula mass (M_r) of 81.

The formula of this metal oxide is MO.
(M is **not** the correct symbol for the metal.)

The relative atomic mass (A_r) of oxygen is 16.

(i) Calculate the relative atomic mass (A_r) of metal M.

_____

_____

_____

_____

Relative atomic mass (A_r) = _____

(2)

(ii) Use your answer to part (a)(i) and the periodic table on the Data Sheet to name metal M.

The name of metal M is _____
.

(1)

(b) The other metal oxide is iron(III) oxide.

This contains iron(III) ions (Fe^{3+}) and oxide ions (O^{2-}).

(i) Explain in terms of electrons how an iron atom (Fe) can change into an iron(III) ion (Fe^{3+}).

_____

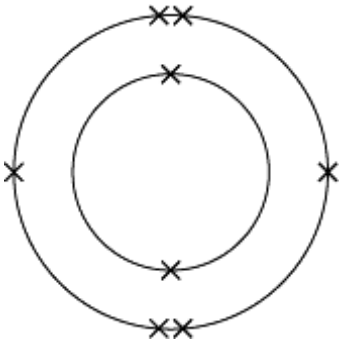
_____

_____

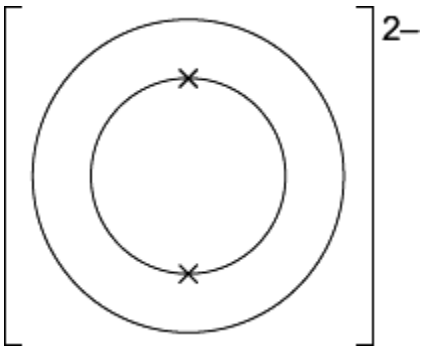
_____

(2)

(ii) The diagram below represents the electronic structure of an oxygen atom (O).



Complete the diagram below to show the electronic structure of an oxide ion (O^{2-}).



(1)

(Total 6 marks)

4. Reactions

Metals can react with oxygen, water and dilute acid. Information about how vigorous these reactions are can be used to place the metals in a reactivity series. Use https://www.bbc.co.uk/bitesize/guides/zy7dgdm/revision/1 and https://www.bbc.co.uk/bitesize/guides/zy7dgdm/revision/2 and your revision guide to complete this summary page

The reactivity series of metals

Metal	Reaction with cold water	Reaction with dilute acids	Reactivity
Potassium	Violent	Violent	Most reactive
Sodium			
Lithium			
Calcium	Fast	Rapid	
Magnesium	Very slow		
(Carbon)			
Zinc	Usually no reaction	Slow	
Iron	Rusts slowly		
(Hydrogen)			
Copper	No reaction	No reaction	
Gold			Least reactive

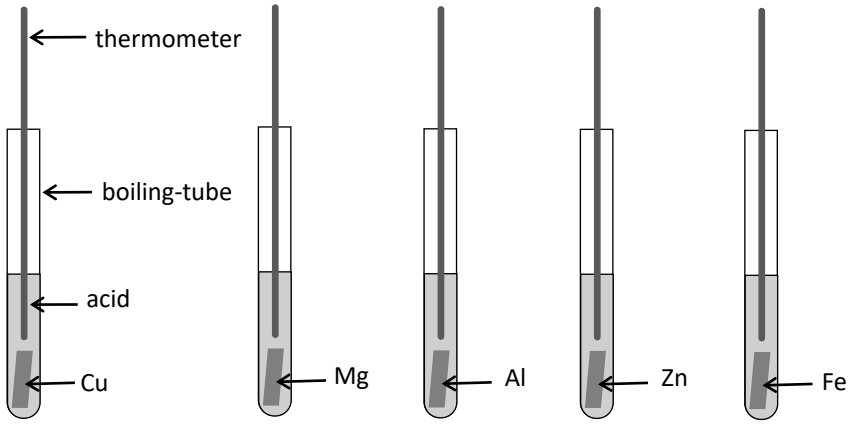
Reaction of metals with water

Reaction of metals with dilute acid

Reactions of metals with oxygen
Displacement in solutions
Deducing a reactivity series
Displacement reactions as redox reactions

3.0 A student investigated the reactivity of metals with acids.
Five different metals were investigated.
Figure 4 shows the apparatus the student used.

Figure 4



The method the student used was:

- measured 10 cm^3 of dilute acid using a 50cm^3 measuring cylinder
- placed 10 cm^3 of dilute acid in a boiling tube
- added a 2 cm length of metal to the dilute acid
- measured the highest temperature reached
- repeated the experiment using different metals.

Table 1 shows the student's results

Table 1

Metal	Temperature change (°C)			
	Test 1	Test 2	Test 3	Mean
Aluminium	33	10	35	
Copper	1	0	2	1
Iron	22	21	20	21
Magnesium	44	46	45	45
Zinc	25	27	26	26

3.1 State the dependent and independent variables in the investigation.

[2 marks]

Dependent variable_____

Independent variable _____

3.2 Name **two** control variables the student kept the same.

[2 marks]

_____

_____

3.3 Calculate the mean temperature change for aluminium.

[1 mark]

Mean temperature change for aluminium = _____ °C

3.4 Suggest **two** changes that could improve the accuracy of the investigation.

[2 marks]

_____

_____

3.5 Use the data in **Table 1** to list the metals in order of reactivity from most reactive to least reactive.

[1 mark]

_____

3.6 Suggest why the student did not use any Group 1 metals in the investigation.

[1 mark]

_____

5. Waves

Use your Guide and sources such as BBC Bitesize to produce your own Summary Sheets about Waves.

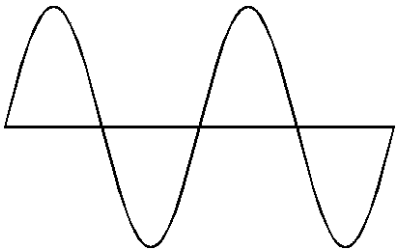
Define the following terms:

Amplitude

Wavelength

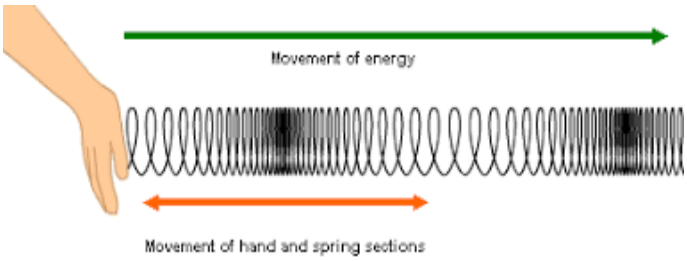
Frequency

Label the diagram with the above keywords



The nature of waves

a. **Waves transfer …….. and not ……**



b. **This is a …….. wave.**

c. **Label: compression, rarefaction and wavelength.**

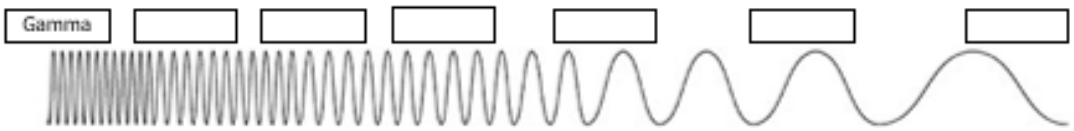
d. **Describe the features of a transverse wave.**

e. What is the difference between longitudinal and transverse waves?
f. List some examples of transverse waves:
g. List some examples of longitudinal waves.
h. Write the equation for calculating wave speed, stating what each of the letters stand for and their units
i. What does the frequency of a wave mean?

6. Use of electromagnetic waves

Electromagnetic waves can be used in communications.

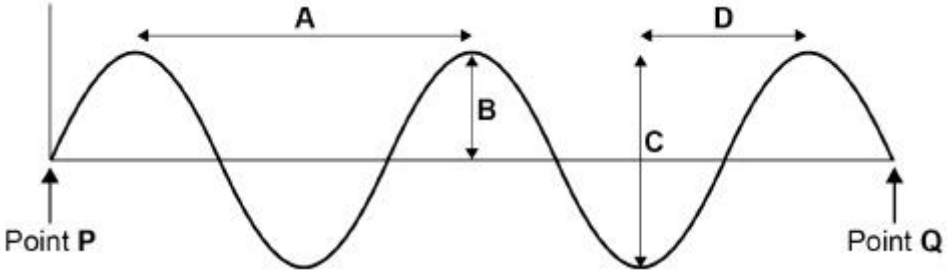
Electromagnetic Spectrum:
Complete the diagram.



Watch the video 'Electromagnetic Waves for Communication'
(https://www.nagwa.com/en/lessons/284131317630/) and summarise the ideas below:

Waves practice questions

1. The diagram shows a wave.



(a) Which arrow shows the amplitude of the wave?

Tick **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(b) Which arrow shows the wavelength of the wave?

Tick **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(c) It takes 0.5 seconds for a wave in the diagram to travel from point **P** to point **Q**.

Calculate the frequency of the waves shown in the diagram.

_____

_____

_____

Frequency = _____ Hz

(2)

(d) What type of wave is sound?

Tick **one** box.

- Electromagnetic ☐
- Longitudinal ☐
- Transverse ☐

(1)

(g) A student compares the properties of visible light waves and radio waves.

Which **two** properties are the same for both visible light waves **and** radio waves?

Tick **two** boxes.

- Both are transverse waves ☐
- Both can travel through a vacuum ☐
- Both have the same amplitude ☐
- Both have the same frequency ☐
- Both have the same wavelength ☐

(2)

2. Waves may be longitudinal or transverse.

(a) Describe the differences between longitudinal waves and transverse waves.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(b) Radio waves are electromagnetic waves.

Describe how radio waves are different from sound waves.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 7 marks)