AQA GCSE CHEMISTRY (HIGHER) · 8462

CHEMISTRY



EXAM QUESTION PACK

4.1.3 PROPERTIES OF TRANSITION METALS

SCORE	PERCENTAGE
/162	%

STEMUP

These questions belong to AQA, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by AQA. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with AQA and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. AQA has not endorsed, approved or been involved in the production of it. AQA and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

AQA publishes its past papers, mark schemes and examiner reports. Always check the current specification at aqa.org.uk before you revise, because content and wording can change between series.

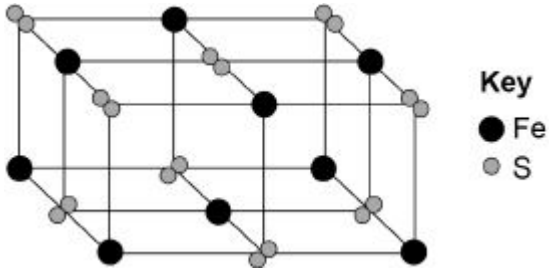
If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Q1.

This question is about metals and metal compounds.

(a) Iron pyrites is an ionic compound.

The diagram below shows a structure for iron pyrites.



Determine the formula of iron pyrites.

Use the diagram above.

_____

(1)

(b) An atom of iron is represented as $^{56}_{26}Fe$

Give the number of protons, neutrons and electrons in this atom of iron.

Number of protons _____

Number of neutrons _____

Number of electrons _____

(3)

(c) Iron is a transition metal.

Sodium is a Group 1 metal.

Give **two** differences between the properties of iron and sodium.

1. _____

_____

2. _____

_____

(2)

Nickel is extracted from nickel oxide by reduction with carbon.

(d) Explain why carbon can be used to extract nickel from nickel oxide.

_____

STEMUP.CO.UK

_____

_____

_____

(2)

(e) An equation for the reaction is:

$$NiO + C \longrightarrow Ni + CO$$

Calculate the percentage atom economy for the reaction to produce nickel.

Relative atomic masses (A_r): C = 12 Ni = 59

Relative formula mass (M_r): NiO = 75

Give your answer to 3 significant figures.

_____

_____

_____

_____

_____

_____

Percentage atom economy = _____ %

(3)

(Total 11 marks)

Q2.

Titanium is a transition metal.

Titanium is extracted from titanium dioxide in a two-stage industrial process.

Stage 1 $TiO_2 + 2\ C + 2\ Cl_2 \longrightarrow TiCl_4 + 2\ CO$

Stage 2 $TiCl_4 + 4\ Na \longrightarrow Ti + 4\ NaCl$

(a) Suggest **one** hazard associated with **Stage 1**.

_____

_____

(1)

(b) Water must be kept away from the reaction in **Stage 2**.

Give **one** reason why it would be hazardous if water came into contact with sodium.

_____

STEMUP.CO.UK

_____

(1)

(c) Suggest why the reaction in **Stage 2** is carried out in an atmosphere of argon and **not** in air.

_____

_____

_____

_____

(2)

(d) Titanium chloride is a liquid at room temperature.

Explain why you would **not** expect titanium chloride to be a liquid at room temperature.

_____

_____

_____

_____

_____

_____

_____

(3)

In **Stage 2**, sodium displaces titanium from titanium chloride.

(e) Sodium atoms are oxidised to sodium ions in this reaction.

Why is this an oxidation reaction?

_____

_____

(1)

(f) Complete the half equation for the oxidation reaction.

$$Na \longrightarrow _____ + _____$$

(1)

(g) In Stage 2, 40 kg of titanium chloride was added to 20 kg of sodium.

The equation for the reaction is:

$$TiCl_4 + 4\ Na \longrightarrow Ti + 4\ NaCl$$

STEMUP.CO.UK

Relative atomic masses (A_r): Na = 23 Cl = 35.5 Ti = 48

Explain why titanium chloride is the limiting reactant.

You **must** show your working.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(h) For a **Stage 2** reaction the percentage yield was 92.3%

The theoretical maximum mass of titanium produced in this batch was 13.5 kg.

Calculate the actual mass of titanium produced.

_____

_____

_____

Mass of titanium = _____ kg

(2)

(Total 15 marks)

Q3.

Older cars are tested each year to measure the amount of pollutants contained in exhaust fumes.

The table below shows the maximum allowed percentages of exhaust pollutants for petrol cars.

Age of car in years	Maximum allowed percentage (%) of exhaust pollutant	
	Carbon monoxide	Unburned hydrocarbons
16−24	0.30	0.02
3−16	0.20	0.02

STEMUP.CO.UK

(a) Explain how carbon monoxide is produced when petrol is burned in car engines.

_____

_____

_____

_____

(2)

(b) Suggest **two** reasons why the maximum allowed percentage of carbon monoxide has been decreased for newer cars.

1. _____

_____

2. _____

_____

(2)

(c) Give **one** reason for having a maximum allowed percentage of unburned hydrocarbons in exhaust fumes.

_____

_____

(1)

Oxides of nitrogen are also pollutants contained in exhaust fumes.

(d) Describe how oxides of nitrogen are produced when petrol is burned in car engines.

_____

_____

_____

_____

(2)

Catalytic converters are fitted to car exhausts to reduce the amount of pollutants released into the atmosphere.

(e) Nitrogen dioxide is an oxide of nitrogen.

Nitrogen dioxide reacts to produce nitrogen and oxygen in catalytic converters.

Complete the equation for this reaction.

The equation should be balanced.

$$___\ NO_2\,(g) \longrightarrow _____ + ___\ O_2\,(g)$$

(2)

STEMUP.CO.UK

(f) Give **two** effects of atmospheric pollution which are reduced by using catalytic converters.

1. _____

_____

2. _____

_____

(2)

(g) The catalyst in catalytic converters is a mixture of three elements.

Where in the periodic table are these elements most likely to be found?

Tick **one** box.

Alkali metals ☐

Halogens ☐

Noble gases ☐

Transition metals ☐

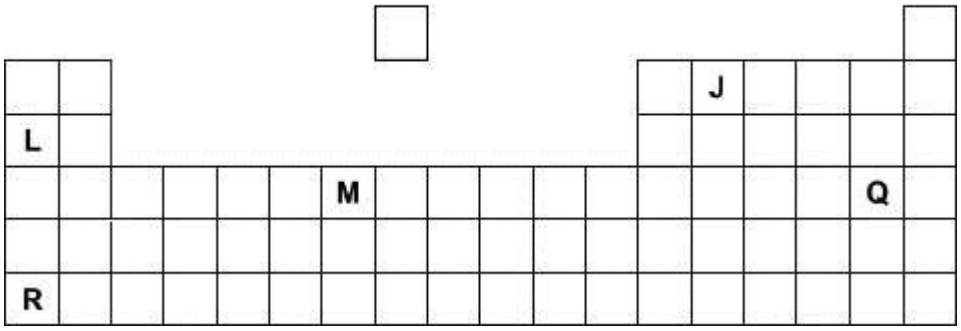
(1)

(Total 12 marks)

Q4.

Figure 1 shows an outline of the modern periodic table.

Figure 1



J, **L**, **M**, **Q** and **R** represent elements in the periodic table.

(a) Which element has four electrons in its outer shell?

Tick (✔) **one** box.

STEMUP.CO.UK

J ☐ L ☐ M ☐ Q ☐ R ☐

(1)

(b) Which **two** elements in **Figure 1** are in the same period?

_____ and _____

(1)

(c) Which element reacts with potassium to form an ionic compound?

Tick (✔) **one** box.

J ☐ L ☐ M ☐ Q ☐ R ☐

(1)

(d) Which element forms ions with different charges?

Tick (✔) **one** box.

J ☐ L ☐ M ☐ Q ☐ R ☐

(1)

(e) Which element has three electron shells?

Tick (✔) **one** box.

J ☐ L ☐ M ☐ Q ☐ R ☐

(1)

(f) In the 1860s scientists were trying to organise elements.

Figure 2 shows the table published by John Newlands in 1865.
The elements are arranged in order of their atomic weights.

Figure 2

H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe
Co,Ni	Cu	Zn	Y	In	As	Se
Br	Rb	Sr	Ce,La	Zr	Di,Mo	Ro,Ru
Pd	Ag	Cd	U	Sn	Sb	Te

STEMUP.CO.UK

Figure 3 shows the periodic table published by Dmitri Mendeleev in 1869.

Figure 3

H							
Li	Be	B	C	N	O	F	
Na	Mg	Al	Si	P	S	Cl	
K Cu	Ca Zn	? ?	Ti ?	V As	Cr Se	Mn Br	Fe Co Ni
Rb Ag	Sr Cd	Y In	Zr Sn	Nb Sb	Mo Te	? I	Ru Rh Pd

Mendeleev's table became accepted by other scientists whereas Newlands' table was not.

Evaluate Newlands' and Mendeleev's tables.

You should include:

- a comparison of the tables
- reasons why Mendeleev's table was more acceptable.

Use **Figure 2** and **Figure 3** and your own knowledge.

(6)

(Total 11 marks)

Q5.

Cobalt forms coloured compounds.

A pink cobalt compound reacts with hydrochloric acid.

The reaction can be represented as:

pink cobalt compound + hydrochloric acid ⇌ blue cobalt compound + water

The forward reaction is endothermic.

When both cobalt compounds are present in a solution at equilibrium, the equilibrium mixture is purple.

(a) What is meant by equilibrium?

_____

_____

_____

_____

(2)

(b) The equilibrium mixture is cooled.

STEMUP.CO.UK

Explain what happens to the concentration of the pink cobalt compound.

_____

_____

_____

_____

_____

_____

(3)

(c) More hydrochloric acid is added.

Explain what happens to the colour of the equilibrium mixture

_____

_____

_____

_____

_____

_____

(3)

(d) Why does cobalt form different coloured compounds?

_____

(1)

(e) An oxide of cobalt has the formula Co_2O_3

Which cobalt ion is present in this oxide?

Tick (✔) **one** box.

Co^{+} ☐

Co^{2+} ☐

Co^{3+} ☐

Co^{4+} ☐

(1)

STEMUP.CO.UK

(f) Cobalt compounds can act as catalysts.

Which two statements about cobalt compounds are correct?

Tick (✔) **two** boxes.

They allow reactions to reach equilibrium more quickly.	☐
They are reactants in reactions catalysed by cobalt compounds.	☐
They are used up when acting as catalysts.	☐
They increase the equilibrium yield of reactions.	☐
They provide a different reaction pathway.	☐

(2)

(g) The reaction of hydrogen with carbon monoxide is catalysed by cobalt metal.

Balance the equation for the reaction.

$$H_2 \quad + \quad CO \quad \longrightarrow \quad C_6H_{14} \quad + \quad H_2O$$

(1)

(h) C_6H_{14} is an alkane.

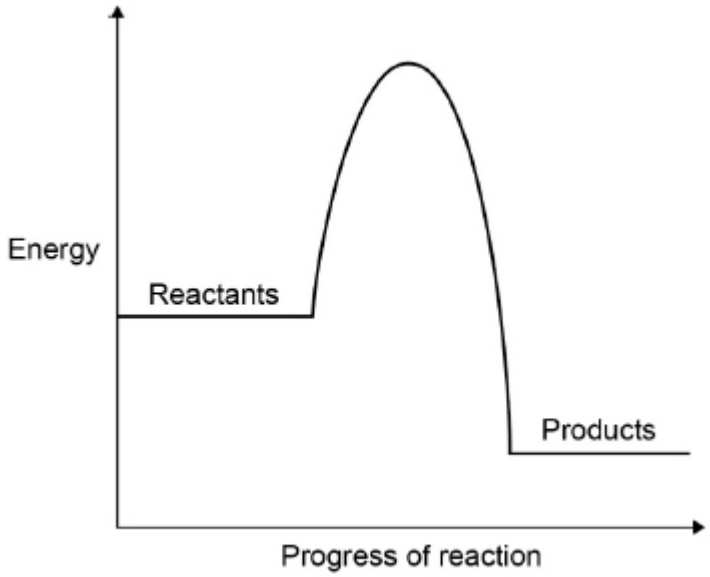
What is the formula of an alkane containing 18 hydrogen atoms?

_____

(1)

(i) The graph shows a reaction profile diagram for a reaction **without** a catalyst.

STEMUP.CO.UK



On the graph:

- draw the reaction profile diagram for a catalysed reaction
- draw and label an arrow to show the activation energy for the reaction **without** a catalyst.

(2)

(Total 16 marks)

Q6.

An atom of aluminium has the symbol $^{27}_{13}Al$

(a) Give the number of protons, neutrons and electrons in this atom of aluminium.

Number of protons _____

Number of neutrons _____

Number of electrons _____

(3)

(b) Why is aluminium positioned in Group 3 of the periodic table?

_____

_____

(1)

(c) In the periodic table, the transition elements and Group 1 elements are metals.

Some of the properties of two transition elements and two Group 1 elements are shown in the table below.

	Transition elements	**Group 1 elements**

STEMUP.CO.UK

	Chromium	Iron	Sodium	Caesium
Melting point in °C	1857	1535	98	29
Formula of oxides	CrO Cr_2O_3 CrO_2 CrO_3	FeO Fe_2O_3 Fe_3O_4	Na_2O	Cs_2O

Use your own knowledge **and** the data in the table above to compare the chemical and physical properties of transition elements and Group 1 elements.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(6)

(Total 10 marks)

Q7.

Copper is a transition metal.

(a) (i) Where is copper in the periodic table?

Tick (✓) **one** box.

in the central block ☐

in Group 1 ☐

STEMUP.CO.UK

in the noble gas group ☐

(1)

(ii) What is a property of copper?

Tick (✓) **one** box.

breaks easily ☐

conducts electricity ☐

does not conduct heat ☐

(1)

(b) Copper ores are quarried by digging large holes in the ground, as shown in **Figure 1**.

Figure 1



© photllurg/iStock/Thinkstock

Give **two** reasons why quarrying is bad for the environment.

_____

_____

_____

STEMUP.CO.UK

_____

(2)

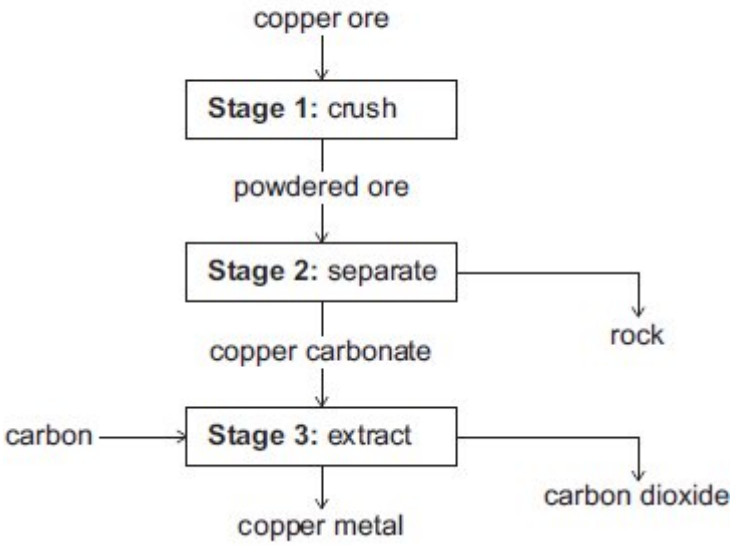
(c) Some copper ores contain only 2% copper.

Most of the ore is rock that is not needed.

In one ore, the main compound is copper carbonate ($CuCO_3$).

Figure 2 shows the stages used in the extraction of copper from this ore.

Figure 2



(i) Why is **Stage 2** important?

_____

_____

(1)

(ii) The equation for the reaction in **Stage 3** is:

$$2\ CuCO_3 + C \longrightarrow 2\ Cu + 3\ CO_2$$

From the symbol equation, a company calculated that 247 tonnes of copper carbonate are needed to produce 127 tonnes of copper and 132 tonnes of carbon dioxide are released.

Calculate the mass of carbon needed to make 127 tonnes of copper.

copper carbonate	+	carbon	⟶	copper	+	carbon dioxide
247 tonnes		..... tonnes		127 tonnes		132 tonnes

_____

_____

(2)

STEMUP.CO.UK

(iii) Suggest **one** reason why it is important for the company to calculate the mass of reactants in **Stage 3**.

_____

_____

(1)

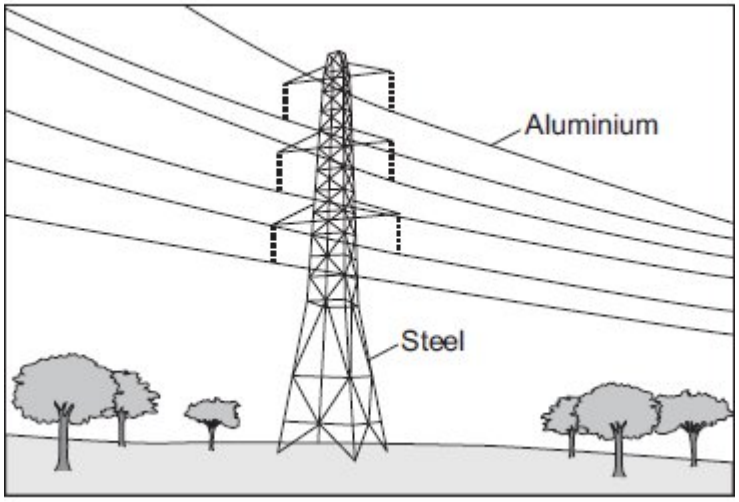
(Total 8 marks)

Q8.

This question is about metals.

Figure 1 shows the metals used to make pylons and the wires of overhead cables.

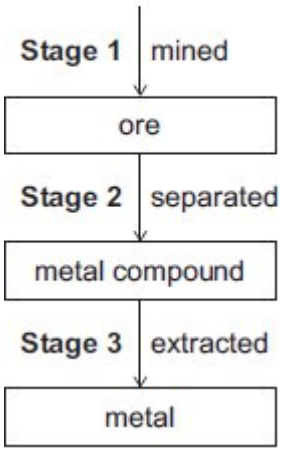
Figure 1



(a) An ore contains a metal compound.

A metal is extracted from its ore in three main stages, as shown in **Figure 2**.

Figure 2



Explain why **Stage 2** needs to be done.

_____

STEMUP.CO.UK

_____

_____

_____

(2)

(b) Cast iron from a blast furnace contains 96% iron and 4% carbon.

(i) Cast iron is not suitable for the manufacture of pylons.

Give **one** reason why.

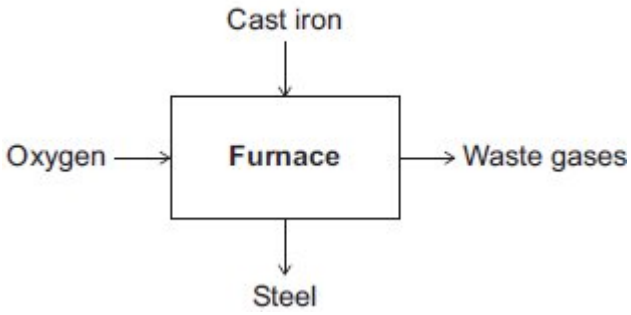
_____

_____

(1)

(ii) Most cast iron is converted into steel, as shown in **Figure 3**.

Figure 3



Describe how cast iron is converted into steel.

Use **Figure 3** to help you to answer this question.

_____

_____

_____

_____

(2)

(c) Aluminium and copper are good conductors of electricity.

(i) State **one** property that makes aluminium more suitable than copper for overhead cables.

_____

_____

(1)

(ii) How can you tell that copper is a transition metal and aluminium is **not** a transition metal from the position of each metal in the periodic table?

STEMUP.CO.UK

_____

_____

_____

_____

(2)

(iii) Copper can be extracted from solutions of copper salts by adding iron.

Explain why.

_____

_____

_____

_____

(2)

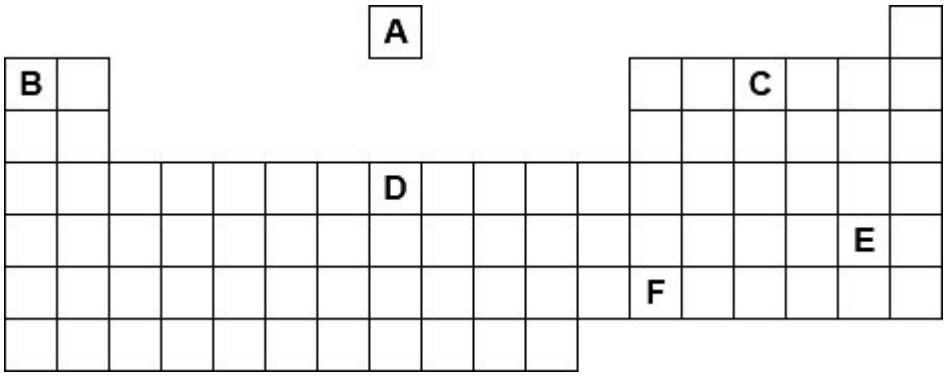
(Total 10 marks)

Q9.

(a) Use the periodic table on the Data Sheet to help you answer these questions.

Part of the periodic table is shown below.

The letters are **not** the symbols of the elements.



Choose your answers **only** from the letters shown in the periodic table above.

Which letter, **A**, **B**, **C**, **D**, **E** or **F**, represents

(i) hydrogen Letter ☐

(1)

(ii) a Group 3 element Letter ☐

STEMUP.CO.UK

(1)

(iii) a halogen Letter ☐

(1)

(iv) the element with atomic (proton) number of 7 Letter ☐

(1)

(v) an element with one electron in its outer shell? Letter ☐

(1)

(b) The table shows the melting points of the Group 1 metals arranged in alphabetical order.

Group 1 metal		
Name	**Symbol**	**Melting point in °C**
Caesium	Cs	29
Francium	Fr	27
Lithium	Li	180
Potassium	K	64
Rubidium	Rb	39
Sodium	Na	98

(i) Arrange these metals in order of increasing melting point. Three have been done for you.

Fr Cs _____ _____ _____ Li

Lowest ⟶ Highest

(1)

(ii) Use the periodic table on the Data Sheet **and** your answer in part (b)(i) above to complete this sentence about how the melting points change.

Going down Group 1, the melting points _____

(1)

(c) The transition metals are a block of elements between Groups 2 and 3 of the periodic table. Transition metals have different properties to Group 1 metals.

STEMUP.CO.UK

Put ticks (✓) next to the **three** correct statements about transition metals in the table below.

Statement	(✓)
They are harder than Group 1 metals	
They have lower densities than Group 1 metals	
They have higher melting points than Group 1 metals	
They are more reactive with water than Group 1 metals	
They often form coloured compounds but Group 1 compounds are usually white	

(3)

(Total 10 marks)

Q10.

Sodium is a Group 1 element.

(a) (i) A small piece of sodium is added to some water containing Universal Indicator solution.

Describe what you would **see** happening.

_____

_____

_____

_____

_____

_____

(3)

(ii) Complete **and** balance the equation for the reaction of sodium with water.

___Na + ___H_2O → _____ + H_2

(2)

(b) Francium is the most reactive element in Group 1.

Explain why in terms of electronic structure.

_____

_____

_____

STEMUP.CO.UK

_____

_____

_____

(3)

(c) The transition elements have different properties from the elements in Group 1.

Give **two** of these different properties of transition elements.

1. _____

_____

2. _____

_____

(2)

(Total 10 marks)

Q11.

The periodic table on the Data Sheet may help you to answer some of these questions.

(a) Draw a ring around the correct answer to complete these sentences.

(i)

Dimitri Mendeleev attempted to classify

compounds.
elements.
mixtures.

(1)

(ii)

He arranged them in order of their

atomic weight.
boiling point.
electrical conductivity.

(1)

(iii)

They are now arranged in order of their

atomic (proton) number.
atomic weight.
mass number.

(1)

STEMUP.CO.UK

(b) In the periodic table between Groups 2 and 3 there is a block of metals which includes chromium, iron and nickel.

(i) Which **one** of the following is the correct name for this block of metals?

Draw a ring around the correct answer.

alkali metals **reactive metals** **transition metals**

(1)

(ii) The properties of iron and those of the Group 1 metal sodium are different.

Put a tick (✓) next to the **two** correct phrases which could complete the following sentence.

Compared to sodium, iron

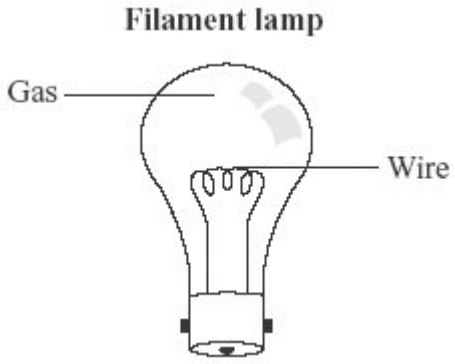
	(✓)
has a higher melting point.	
has a lower density.	
is harder.	
is more reactive.	
is weaker.	

(2)

(Total 6 marks)

Q12.

When electricity passes through a thin wire, the wire gets hot. If the wire gets very hot, it may glow. This idea is used in filament lamps.



(a) The table shows some metals and their melting points.

Metal	Melting point in °C
Aluminium	660
Copper	1084

STEMUP.CO.UK

Iron	1540
Tungsten	3410

Which metal in the table should be used to make the wire in a filament lamp?

Give a reason for your answer.

_____

_____

_____

_____

(2)

(b) The table shows some gases.

Gas
Argon
Carbon dioxide
Oxygen
Sulfur dioxide

Which gas in the table should be used in a filament lamp?

Give a reason for your answer.

_____

_____

_____

_____

(2)

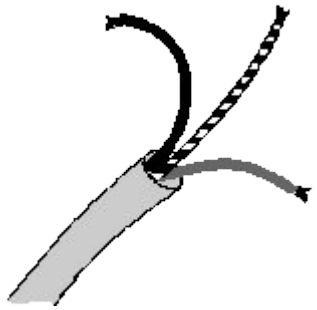
(Total 4 marks)

Q13.

The properties of transition metals make them useful elements.

(a) Why is copper used for electrical wiring?

STEMUP.CO.UK

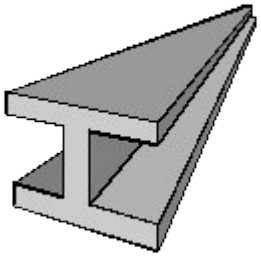


_____

_____

(1)

(b) Why is iron used for girders in buildings?



_____

_____

(1)

(c) Why are transition metal compounds added to glazes for pottery?



_____

_____

(1)

(Total 3 marks)

Q14.

Niobium is a typical transition metal.

Put a tick (✓) next to each of the **four** properties in the table that you would expect for Niobium.

STEMUP.CO.UK

Property	
brittle	
conducts heat	
dull	
forms coloured compounds	
high melting point	
low boiling point	
strong	
very reactive	

(Total 4 marks)

Q15.

Transition elements and their compounds have many uses.

Iron oxide and cobalt oxide have been added to the glazes on pottery for hundreds of years.



(a) State why transition metal oxides are added to pottery glazes.

_____

(1)

(b) Use the table of ions on the Data Sheet to help you work out the formula of iron(III) oxide.

_____

(1)

(c) Cobalt oxide is reacted with hydrogen to form cobalt.

(i) Balance the equation for this reaction.

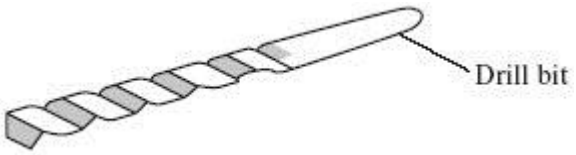
STEMUP.CO.UK

$Co_3O_4 + \ldots\ldots H_2 \rightarrow 3\,Co + \ldots\ldots H_2O$

(1)

(ii) Cobalt is mixed with other transition metals to make alloys.

These alloys are used to make cutting tools which remain sharp at very high temperatures. They can cut through other metals.



Suggest **two** properties of transition metals that make them suitable for making cutting tools.

1. _____

_____

2. _____

_____

(2)

(Total 5 marks)

Q16.

The extract below was taken from a leaflet on the uses of platinum. One of the uses described was in making electrodes for spark plugs in car engines. The spark plug produces the spark which ignites the fuel in the engine.

Spark Plugs

The electrodes in a spark plug have to conduct electricity very well. Since they project into the combustion chamber of the engine, they must also be able to withstand extremely high temperatures in a very corrosive atmosphere.

Nickel-based plugs have been produced for many years. They only last a fairly short time. As the electrodes wear, combustion becomes less efficient and the petrol is not burnt completely.

Platinum and other precious metals can now be used in spark plugs. These last much longer and are more efficient. This can help to reduce air pollution.

The table below gives some information about platinum and nickel.

	MELTING POINT (° C)	BOILING POINT (° C)	POSITION IN REACTIVITY SERIES	COST (£/kg)
nickel	1455	2920	Higher than gold	2.5
platinum	1769	4107	below gold	6110

STEMUP.CO.UK

(a) Compare nickel and platinum for use in making the electrodes in spark plugs.

A good answer should give advantages and disadvantages of each metal linking these to the properties of the metals. Marks will be given for the way in which you organise your answer.

You will need a sheet of lined paper.

(8)

(b) (i) Describe the structure and bonding in metals.

_____

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(ii) Explain why metals such as nickel and platinum are good conductors of electricity.

_____

_____

_____

(2)

(Total 13 marks)

Q17.

The table shows the % composition by mass of modern British coins.

COIN	% COMPOSITION BY MASS			
	copper	nickel	tin	zinc
£1	70	5.5	–	24.5
20p	84	16	–	–
5p, 10p, & 50p				

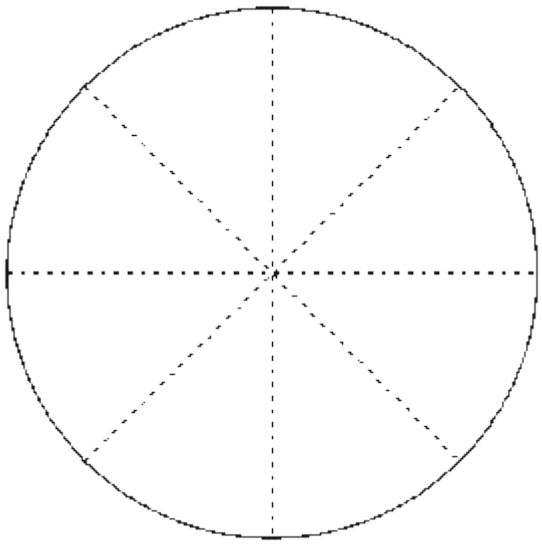
STEMUP.CO.UK

1p &2p (until 1991)	97	–	0.5	2.5
1p &2p (1992 onwards)	Copper plated steel			

(a) Use the Data Sheet to help you to complete the table by filling in the information about 5p, 10p and 50p coins which are made of cupronickel.

(1)

(b) Shade the pie chart to represent the % of copper in a £1 coin.



(1)

(c) Name the metal present in:

(i) all these coins,

_____

(1)

(ii) a £1 coin but **not** in a 20p coin.

_____

(1)

(d) The following is a list of properties.

- bends easily
- good conductor of electricity
- hard
- high melting point
- poor conductor of heat
- unreactive

STEMUP.CO.UK

From this list, choose two properties which coinage metals should have. For each property, give a reason for your answer.

Property 1 _____

Reason _____

Property 2 _____

Reason _____

(2)

(Total 6 marks)

Q18.

(a) What is the name given to the block of elements in the middle of the Periodic Table which includes vanadium?

_____

(1)

(b) Some of the properties of vanadium are shown in this list.

- It has a high melting point.
- It is a solid at room temperature.
- It is a conductor of electricity.
- It is a good conductor of heat.
- It forms coloured compounds.
- If forms crystalline compounds.
- It forms compounds that are catalysts.

Select **two** properties, from the list above, which are **not** typical of a Group 1 metal.

1. _____

2. _____

(2)

(Total 3 marks)

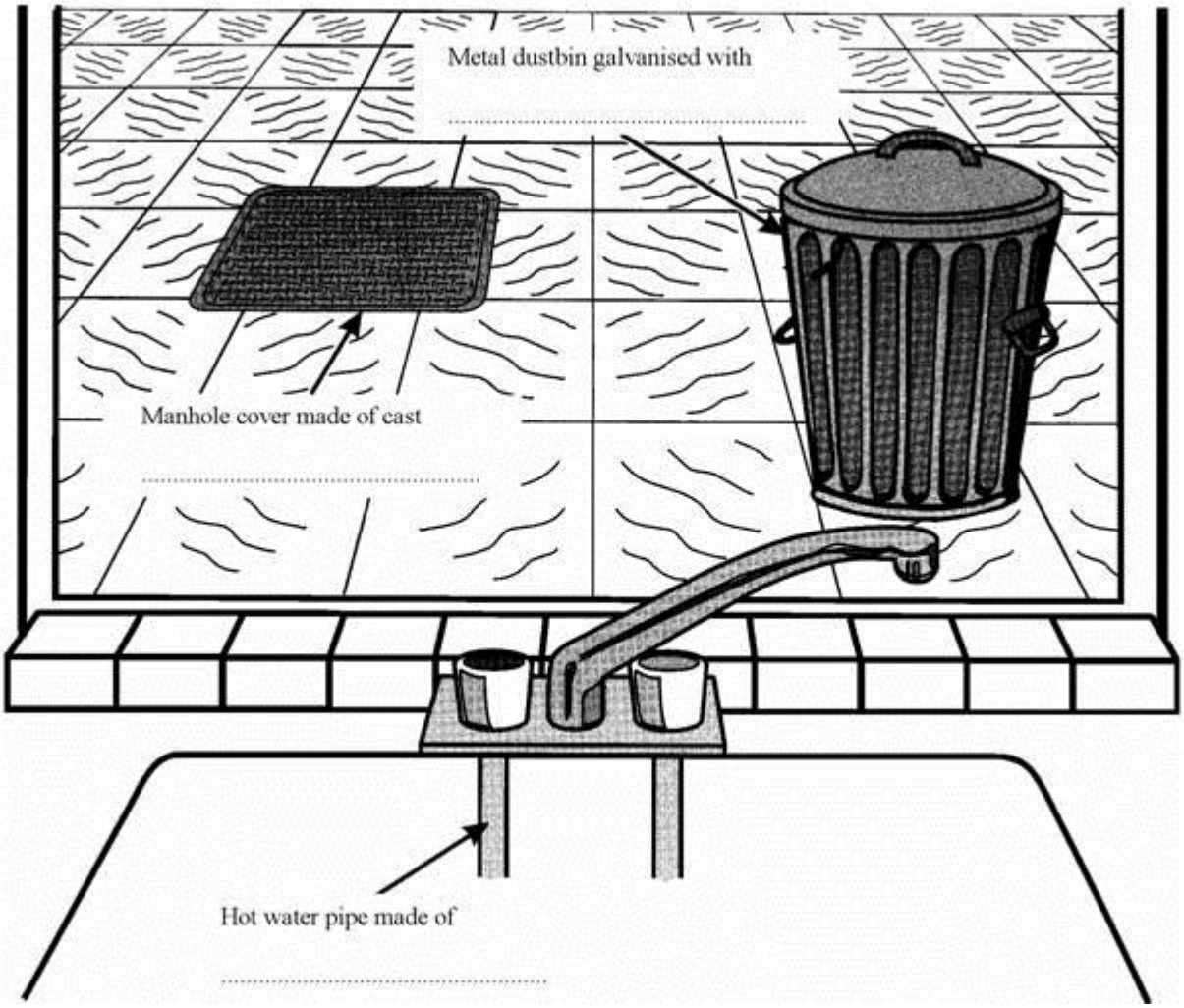
Q19.

The word box contains the names of some metals.

aluminium	copper	iron	manganese	zinc

(i) The drawing shows the view from a window. Choose from the names of metals in the box to complete the **three** spaces.

STEMUP.CO.UK



(3)

(ii) What is the name of the metal in the word box which has the chemical symbol Fe?

_____

(1)

(iii) What is the name of **one** metal in the word box which often has coloured compounds?

_____

(1)

(Total 5 marks)

STEMUP.CO.UK