Properties of Transition Metals

These practice questions can be used by students and teachers and is suitable for GCSE AQA Chemistry topic Questions 8462

Level: GCSE AQA Chemistry 8462

Subject: Chemistry

Exam board: GCSE AQA

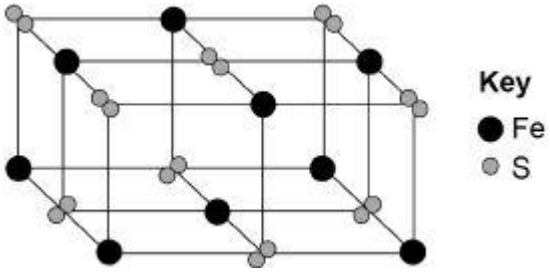
Topic: Properties of Transition Metals

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.

_____

(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.

(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:

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

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

(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)

(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 ☐

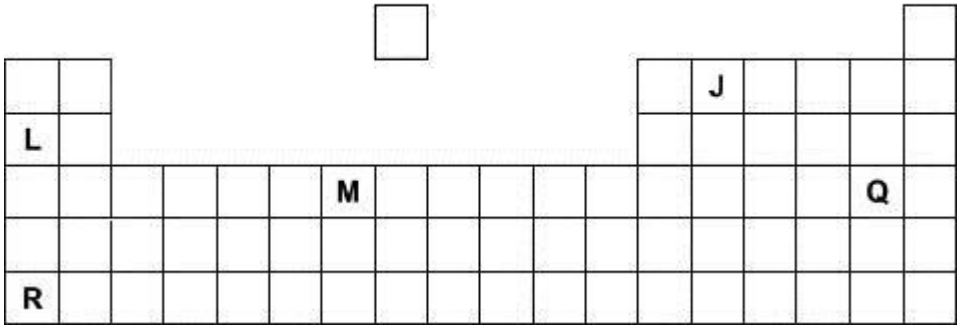
(1)

(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.

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

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.

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)

(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)

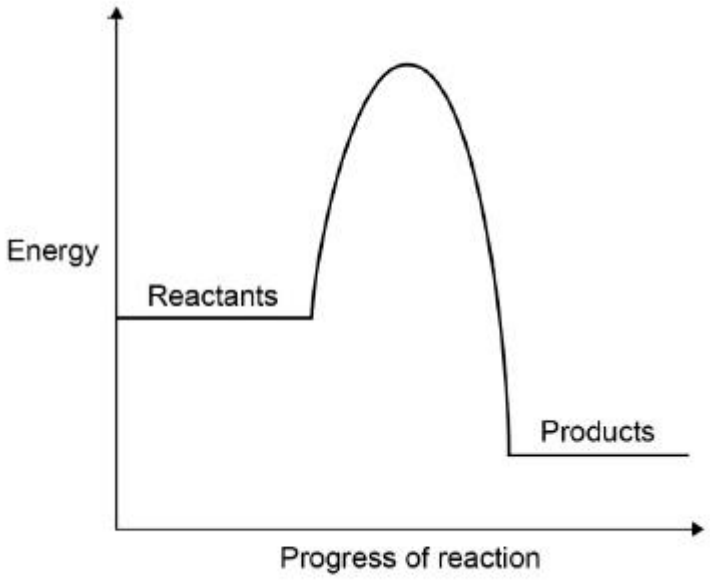
(h) C_6H_{14} is an alkane.

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.



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	
	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 ☐

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.

(2)

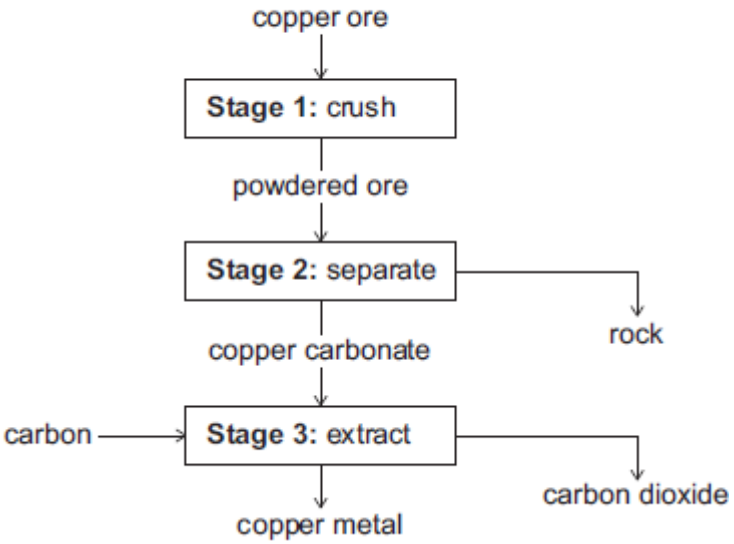
(c) Some copper ores contain only 2% copper.

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)

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

_____

_____

(1)

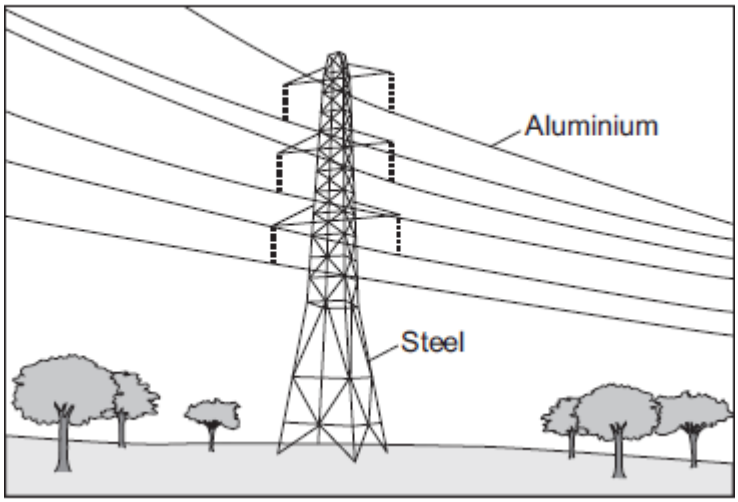
(Total 8 marks)

Q8.

This question is about metals.

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

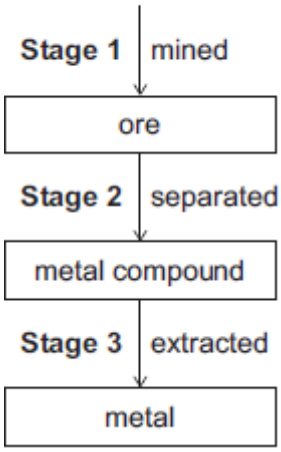
Figure 1



(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.

_____

_____

_____

_____

(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.

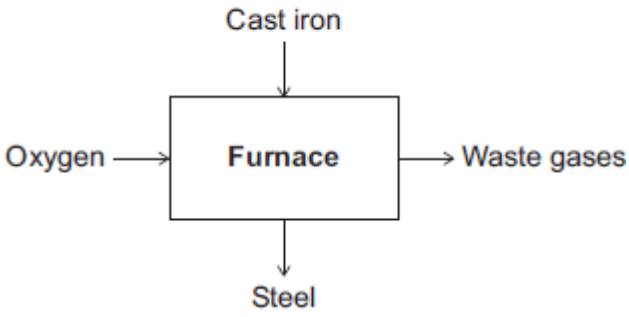
_____

_____

(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?

(2)

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

Explain why.

(2)

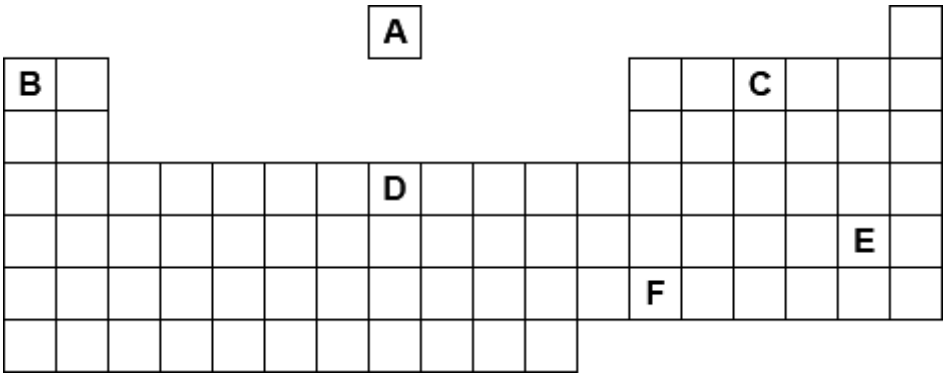
(Total 10 marks)

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 ☐

(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.

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.

_____

_____

_____

_____

_____

_____

(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)

(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

	(✓)

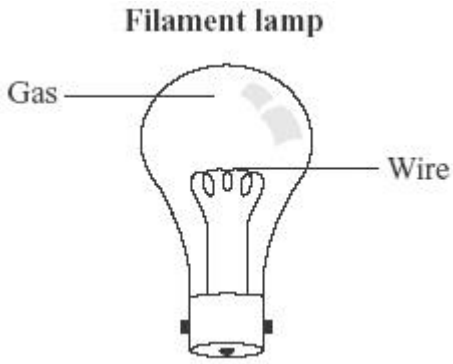
has a higher melting point.	
has a lower density.	
is harder.	
is more reactive.	
is weaker.	

(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
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.

_____

_____

_____

_____

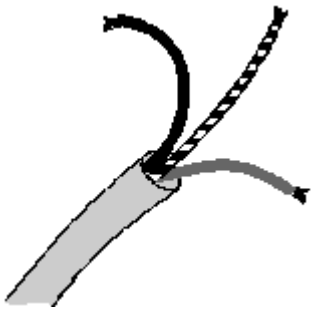
(2)

(Total 4 marks)

Q13.

The properties of transition metals make them useful elements.

(a) Why is copper used for electrical wiring?

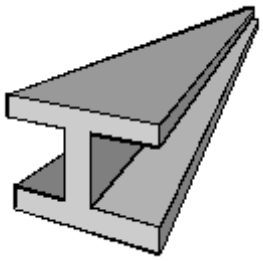


_____

_____

(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.

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.

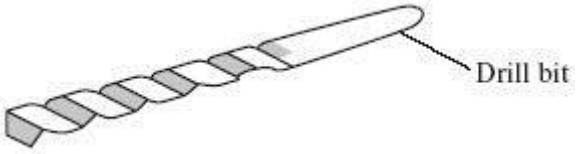
(i) Balance the equation for this reaction.

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

(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

(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.

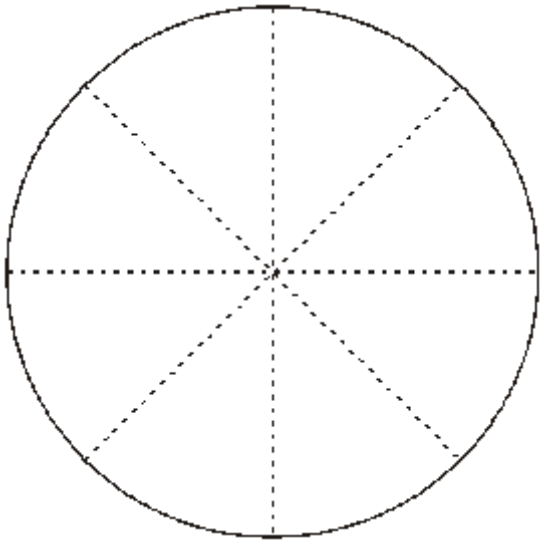
The table shows the % composition by mass of modern British coins.

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

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)

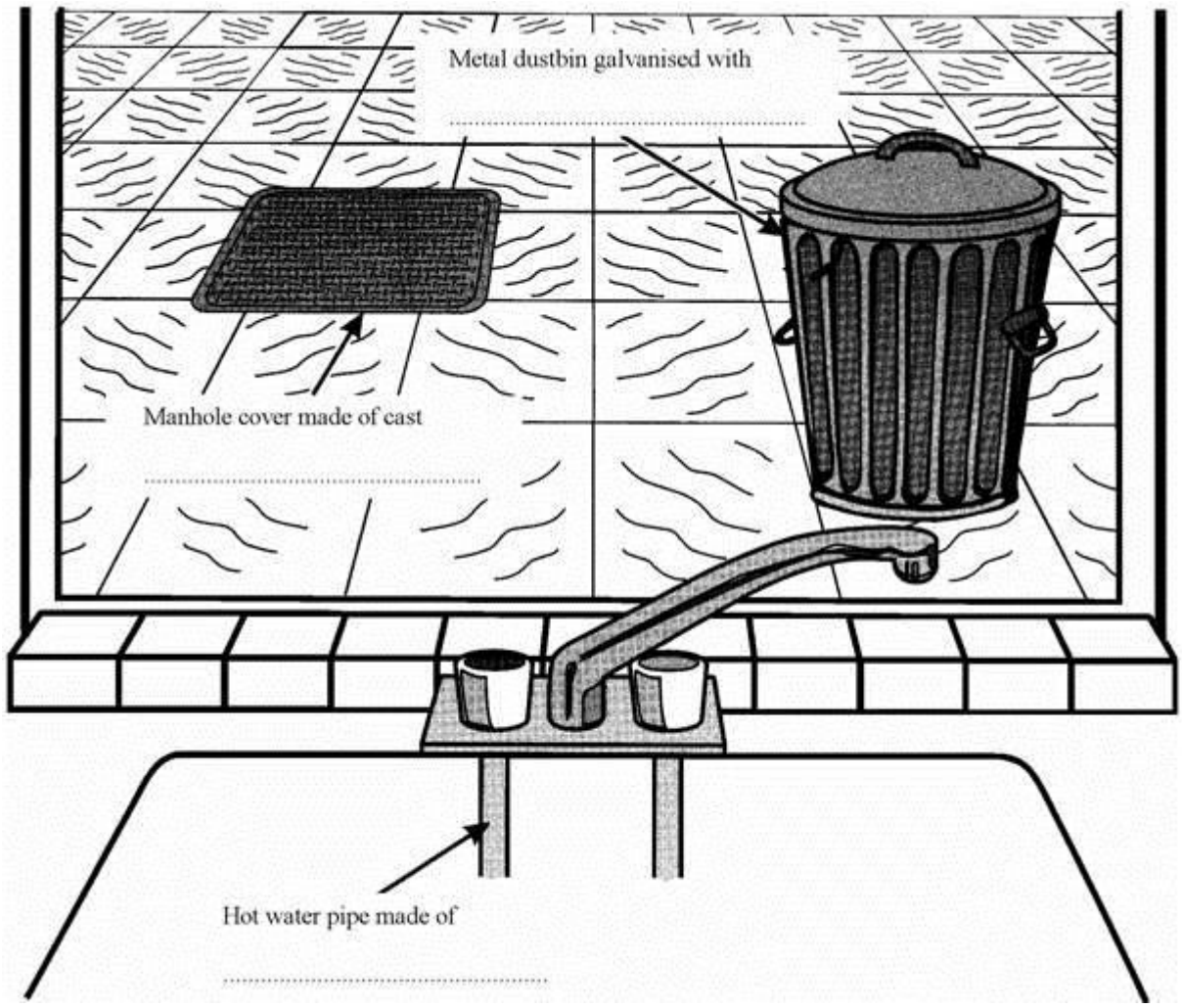
(Total 3 marks)

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.



(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)

Mark schemes

Q1.

(a) FeS_2

*do **not** accept equations*

1

(b) 26

1

30

1

26

1

must be this order

(c) any **two** from:

- iron has a high(er) melting / boiling point
- iron is dense(r)
- iron is hard(er)

allow iron is less malleable / ductile

- iron is strong(er)
- iron is less reactive

allow specific reactions showing difference in reactivity

- iron has ions with different charges
- iron forms coloured compounds
- iron can be a catalyst

allow iron is magnetic

allow the converse statements for sodium
allow transition metal for iron
allow Group 1 metal for sodium

ignore references to atomic structure

ignore iron rusts

2

(d) carbon is more reactive (than nickel)

allow converse

1

(so) carbon will displace / replace nickel (from nickel oxide)

allow (so) nickel ions gain electrons

or

(so) carbon will remove oxygen (from nickel oxide)

allow (so) carbon transfers electrons to nickel (ions)

1

(e) (total M_r of reactants =) 87

1

(percentage atom economy)

$= \frac{59}{87} \times 100$

allow (percentage atom economy)
$= \frac{59}{\text{incorrectly calculated } M_r} \times 100$

1

= 67.8 (%)

allow an answer from an incorrect calculation to 3 sig figs

1

*an answer of 67.8 (%) scores **3** marks*
*an answer of 67.8160919 (%) or correctly rounded answer to 2, 4 or more sig figs scores **2** marks*
an incorrect answer for one step does not prevent allocation of marks for subsequent steps

[11]

Q2.

(a) chlorine is toxic

allow carbon monoxide is toxic
allow poisonous for toxic
ignore harmful / deadly / dangerous
allow a poisonous gas is used / produced
allow titanium chloride is corrosive

1

(b) any **one** from:

- very exothermic reaction

allow explosive
allow violent reaction
ignore vigorous reaction
ignore sodium is very reactive

- produces a corrosive solution

allow caustic for corrosive
ignore alkaline

- produces hydrogen, which is explosive / flammable

allow flames produced
ignore sodium burns

1

(c) argon is unreactive / inert

allow argon will not react (with reactants / products / elements)

1

oxygen (from air) would react with sodium / titanium
or
water vapour (from air) would react with sodium / titanium

allow elements / reactants / products for sodium / titanium

1

(d) metal chlorides are usually ionic

allow titanium chloride is ionic

1

(so)(metal chlorides) are solid at room temperature
or
(so)(metal chlorides) have high melting points

allow titanium chloride for metal chlorides

1

(because) they have strong (electrostatic) forces between the ions

ignore strong ionic bonds

or
(but) must be a small molecule or covalent

allow molecular

1

allow alternative approach:
*titanium chloride must be covalent **or** has small molecules (1)*
with weak forces between molecules
*do **not** accept bonds unless intermolecular bonds(1)*
(but) metal chlorides are usually ionic (1)

(e) sodium (atoms) lose electrons

*do **not** accept references to oxygen*

1

(f) $Na \longrightarrow Na^{+} + e^{-}$

*do **not** accept e for e^{-}*

1

(g) (M_r of $TiCl_4$ =) 190

$$(\text{moles Na} = \frac{20\,000}{23} =) \ 870 \ (\text{mol}) \ *$$

1

$$(\text{moles } TiCl_4 = \frac{40\,000}{190} =) \ 211 \ (\text{mol}) \ *$$

1

allow **1 mark for 0.870 mol Na **and** 0.211 mol $TiCl_4$*
allow use of incorrectly calculated M_r from step 1

either

(sodium is in excess because) 870 mol Na is more than the 844 mol needed
or
(because) 211 mol $TiCl_4$ is less than the 217.5 mol needed

the mark is for correct application of the factor of 4

other correct reasoning showing, with values of moles or mass, an excess of sodium or insufficient $TiCl_4$ is acceptable

allow use of incorrect number of moles from steps 2 and / or 3

1

alternative approaches:

approach 1:

(M_r of $TiCl_4$ =) 190(1)

(40 kg $TiCl_r$ needs)

$\frac{40}{190} \times 4 \times 23$ *(kg Na) (1)*

(=) 19.4 (kg) (1)

so 20 kg is an excess (1)

approach 2:

(M_r of $TiCl_4$ =) 190(1)

(20 kg Na needs)

$\frac{20}{4 \times 23} \times 190$ *(kg $TiCl_4$) (1)*

(=) 41.3 (kg) (1)

so 40 kg is not enough (1)

(h) (actual mass =) $\frac{92.3}{100} \times 13.5$

or

(actual mass =) 0.923 × 13.5

1

= 12.5 (kg)

allow 12 / 12.46 / 12.461 / 12.4605 (kg)

1

*an answer 12.5 (kg) scores **2** marks*

[15]

Q3.

(a) incomplete combustion

1

(because) insufficient / limited oxygen supply

1

(b) any **two** from:

- carbon monoxide toxic / poisonous

allow description of how carbon monoxide is toxic / poisonous
ignore carbon monoxide is harmful / dangerous / deadly

- greater public concern / awareness about pollution
  ignore comments about the effects of other pollutants
  ignore unspecified comments about carbon monoxide pollution

- more cars so otherwise there would be more carbon monoxide entering atmosphere

- improved engine technology

- catalytic converters have been introduced

2

(c) any **one** from:

- (to reduce) health problems
  allow (to reduce) specified health problems e.g. breathing difficulties, asthma, lung cancer

- (to reduce) global dimming
  allow (to reduce) the effects of global dimming e.g. reduced light levels
  allow (to reduce) smog
  allow (to reduce) the formation of particulates
  ignore global warming
  *do **not** accept to reduce soot*

1

(d) nitrogen (from atmosphere) reacts with oxygen (from atmosphere)

1

at high temperature (in engine)
ignore heat / hot

or
with a spark (from spark plug)

1

(e) **2** $NO_2 \longrightarrow N_2$ + **2** O_2
allow multiples
*if incorrect, allow N_2 for **1** mark*

2

(f) any **one** from:

- acid rain
  allow specific effects of acid rain

- respiratory problems
  allow specific respiratory problems e.g. breathing

difficulties, asthma

- carbon monoxide
- global dimming **or** smog

2

max 1 *mark if global warming mentioned*

(g) transition metals

1

[12]

Q4.

(a) **J**

1

(b) **M** and **Q**

either order

1

(c) **Q**

1

(d) **M**

1

(e) **L**

1

(f) **Level 3 (5-6 marks):**
A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.

Level 2 (3-4 marks):
Some logically linked reasons are given. There may also be a simple judgement.

Level 1 (1-2 marks):
Relevant points are made. They are not logically linked.

Level 0
No relevant content

Indicative content

comparative points
- both tables have more than one element in a box
- both have similar elements in the same column
- both are missing the noble gases
- both arranged elements in order of atomic weight

advantages of Mendeleev / disadvantages of Newlands
- Newlands did not leave gaps for undiscovered elements
- Newlands had many more dissimilar elements in a column
- Mendeleev left gaps for undiscovered elements
- Mendeleev changed the order of some elements (e.g. Te and I)

points which led to the acceptance of Mendeleev's table

- Mendeleev predicted properties of missing elements
- elements with properties predicted by Mendeleev were discovered
- Mendeleev's predictions turned out to be correct
- elements were discovered which fitted the gaps

6

[11]

Q5.

(a) in a closed system

1

the rate of the forward and backward reactions are equal

1

(b) concentration increases

1

(because) reaction / equilibrium moves to the left / reactant side

1

(since the) reverse reaction is exothermic

allow (so that) temperature increases

1

(c) becomes blue

1

(because) reaction / equilibrium moves to the right / product side

1

(so) concentration of blue cobalt compound increases

allow (so that) concentration of hydrochloric acid decreases

1

(d) (cobalt has) ions with different charges

allow (cobalt is a) transition metal

1

(e) Co^{3+}

1

(f) they allow reactions to reach equilibrium more quickly

1

they provide a different reaction pathway

1

(g) $\mathbf{13}H_2 + \mathbf{6}CO \rightarrow C_6H_{14} + \mathbf{6}H_2O$

allow multiples

1

(h) C_8H_{18}

1

(i) curve below printed curve

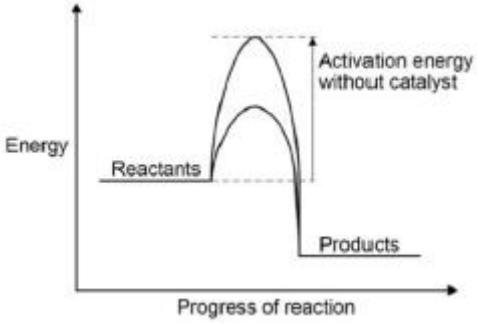
*do **not** accept different reactant or product levels*

1

vertical arrow from reactant level to peak of **printed** curve

1

an answer of:



scores **2** marks

[16]

Q6.

(a) 13 (protons)

The answers must be in the correct order.

*if no other marks awarded, award **1** mark if number of protons and electrons are equal*

1

14 (neutrons)

1

13 (electrons)

1

(b) has three electrons in outer energy level / shell

allow electronic structure is 2.8.3

1

(c) **Level 3 (5–6 marks):**
A detailed and coherent comparison is given, which demonstrates a broad knowledge and understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links.

Level 2 (3–4 marks):
A description is given which demonstrates a reasonable knowledge and understanding of the key scientific ideas. Comparisons are made but may not be fully articulated and / or precise.

Level 1 (1–2 marks):
Simple statements are made which demonstrate a basic knowledge of some of the relevant ideas. The response may fail to make comparisons between the points raised.

0 marks:
No relevant content.

Indicative content

Physical
Transition elements
- high melting points
- high densities
- strong
- hard

Group 1
- low melting points
- low densities
- soft

Chemical
Transition elements
- low reactivity / react slowly (with water or oxygen)
- used as catalysts
- ions with different charges
- coloured compounds

Group 1
- very reactive / react (quickly) with water / non-metals
- not used as catalysts
- white / colourless compounds
- only forms a +1 ion

6

[10]

Q7.

(a) (i) central block

1

(ii) conducts electricity

1

(b) any **two** from:
- visual pollution
- noise pollution
- dust pollution
- habitat destruction.

2

(c) (i) to concentrate the ore / copper carbonate
or
to remove / separate the rock

1

(ii) 12 (tonnes)

If answer is incorrect allow one mark for (127 + 132) − 247 or 259 - 247

2

(iii) any **one** from:
- so no reactant is wasted / left unreacted
- so they know how much product they will make
- need to record / compensate for the carbon dioxide produced

allow so they can work out their carbon footprint.

1

[8]

Q8.

(a) The ore is not pure or contains impurities or the ore does not contain 100% of the metal compound

allow to concentrate the metal or metal compound

1

rock / other compounds need to be removed / separated

1

(b) (i) (cast iron is) brittle

allow not strong

ignore weak

1

(ii) the oxygen reacts with carbon

allow carbon burns in oxygen or is oxidised

1

reducing the percentage of carbon in the mixture
or producing carbon dioxide

1

(c) (i) aluminium has a low density

1

(ii) (because copper) is in the central / middle (block of the periodic table)

1

whereas aluminium is in Group 3 (of the periodic table)

1

(iii) iron is more reactive (than copper)

ignore cost

1

so copper is displaced / reduced

1

[10]

Q9.

(a) (i) **A**

1

(ii) **F**

1

(iii) **E**

1

(iv) **C**

1

(v) **A or B**

1

(b) (i) Rb K Na

allow rubidium, potassium, sodium

*do **not** accept RB or NA*

1

(ii) decrease

or

become lower / smaller / less

allow from 180° C to 27° C

1

(c) They are harder than Group 1 metals.

1

They have higher melting points than Group 1 metals.

1

They often form coloured compounds but Group 1 compounds are usually white.

1

[10]

Q10.

(a) (i) UI / solution turns blue / purple

allow violet / lilac

1

any **two** from:

- floats
- melts / forms a sphere
- moves

  *note: moves on surface = **2** marks (points 1 and 3)*
- effervescence / fizz / bubbles / gas

  ignore the name of the gas
- (yellow) flame

  ignore sparks / ignites / burns

  allow dissolves
- reduces in size

  ignore 'reacts violently' unqualified

  ignore reference to exothermic / heat evolved

2

(ii) **2**Na + **2**H_2O → **2NaOH** + H_2

*correct equation = **2** marks*

allow correct multiples / fractions
if this equation is unbalanced,
*allow **1** mark for NaOH*

2

(b) *it = francium*
*outer electron / shell / energy level must be mentioned once for all **3** marks*

biggest atom **or** (outer) shell / energy level / electron furthest from nucleus **or** most (number of) shells

1

least attraction (to nucleus) **or** most shielding
allow the attraction is very weak
*do **not** allow less magnetic / gravitational attraction*

1

(outer) electron more easily lost / taken
ignore francium reacts more easily / vigorously

1

(c) any **two** from:
ignore other properties / specific reactions
they / it = transition elements

transition elements:
allow if state group 1 elements

- high melting point **or** high boiling point
  - *low melting point or low boiling point*
- high density
  - *low density*
- strong / hard
  - *weak / soft*
- not very reactive
  - *reactive*
- catalysts
  - *not catalysts*
- ions have different charges
  - *+1 ions*
- coloured compounds
  - *white compounds*

2

[10]

Q11.

(a) (i) elements

1

(ii) atomic weight

1

(iii) atomic (proton) number

1

(b) (i) transition metals

1

(ii) has a higher melting point is harder

2

[6]

Q12.

(a) tungsten

1

has the high(est) melting point

accept that metals other than tungsten are likely to melt

1

(b) argon

1

is an unreactive gas

accept that gases other than argon are reactive
accept that argon is a noble gas or in Group 0

1

[4]

Q13.

(a) (good)conductor of electricity

conductor of electricity and heat (+/–) = 0
*accept can be drawn into wires **or** ductile*
ignore flexible

1

(b) strong

*accept tough **or** hard **or** high tensile strength*

1

(c) reference to colour

1

[3]

Q14.

conducts heat

list principle applies after 4 ticks

1

forms coloured compounds

1

high melting point

1

strong

1

[4]

Q15.

(a) colour

1

(b) Fe_2O_3 or $(Fe^{3+})_2\ (O^{2-})_3$

2 and 3 should be below halfway on Fe and O

1

(c) (i) 4 4

or correct multiples

1

(ii) any **two** from:

ignore references to malleable / ductile / conductivity / stiff / boiling point / density

- high melting point
  accept can withstand high temperatures
- strong / tough
  accept <u>not</u> brittle
- hard
  *do **not** accept flexible*
- not (very) reactive

2

[5]

Q16.

(a) 8 marks Particularly well structured answer with most points mentioned.

7-6 marks Well structured answer. The two metals will have been compared rather than simply listing advantages/disadvantages. Most of the advantages and disadvantages of each metal have been mentioned.

5-3 marks Some structure to the answer. An attempt to compare the metals by giving some advantages and disadvantages.

2-1 marks Little structure or attempt to compare. Marks gained by listing a few advantages or disadvantages.

Advantages of Nickel:
Relatively low cost which makes the sparking plugs cheaper to produce.
Quite high melting point which is needed because the temperature in the engine is very high.
Good conductor of electricity needed to carry electricity into combustion chamber to produce spark.

Disadvantages of Nickel:
Subject to corrosion in engine which means they only last a short time *because nickel is higher in reactivity than platinum.*
Idea that this leads to reduced efficiency, unburnt petrol and air pollution.

Advantages of Platinum:
Less susceptible to corrosion (not corroded) because platinum is very low in reactivity.
Idea that this improves efficiency and reduces pollution.-
Higher melting point than nickel to withstand the high temperatures in the combustion chamber.
Last a lot longer than nickel electrodes due to low reactivity.
(Sensible extension here could be longer service intervals etc.)-
Good conductor of electricity as for nickel.
Extension here could be linked to the idea that the conductivity does not deteriorate as quickly as nickel.)

Disadvantages of Platinum:
Cost *which will make the sparking plug more expensive.*
A good candidate might justify cost by longer life, better fuel consumption and less pollution.

8

(b) (i) giant structure/lattice/regular arrangements of atoms
any for 1 mark

of atoms/of ions (provided free electrons mentioned)
either for 1 mark

delocalised or free electrons
for 1 mark

3

(ii) electrons free/can move
for 1 mark each

2

[13]

Q17.

(a) 75% Cu, 25% Ni
for 1 mark

1

(b) 70% segment shaded

for 1 mark

1

(c) (i) copper

for 1 mark

1

(ii) zinc

for 1 mark

1

(d) 1. hard so will not wear away/scratch

for 1 mark

1

2. unreactive
so does not corrode/dissolve/or other acceptable reason
(not does not react unless acceptable reason)

(If given hard and unreactive allow 1 mark)

for 1 mark

1

[6]

Q18.

(a) transition / transitional metals / elements / d-block

for one mark

1

(b) coloured
catalyst

(*accept* high melting point)

for 1 mark each

2

[3]

Q19.

(i) zinc

accept Zn

1

iron only

accept Fe

1

copper

accept Cu
do not credit iron

1

(ii) iron

1

(iii) copper **or** iron or manganese

*accept Cu **or** Fe **or** Mn*

1

[5]