GCSE · AQA · Chemistry

2 hours 18 questions

Exam Questions

# Properties of Transition Metals

Typical Properties of Transition Metals / Transition Metals vs. Alkali Metals

| | |
|---|---|
| Easy (4 questions) | /30 |
| Medium (10 questions) | /34 |
| Hard (4 questions) | /45 |
| **Total Marks** | **/109** |

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# Easy Questions

**1 (a)** Transition elements are metals with similar properties.

Where are they found in the periodic table?

Tick (✓) **one** box.

| | |
|---|---|
| In Group 1 | |
| Between Group 2 and 3 | |
| In Group 0 | |
| Between Group 4 and 5 | |

.....

**(1 mark)**

**(b)** Which of the following metals are transition elements?

Tick (✓) **two** boxes.

| | |
|---|---|
| Calcium | |
| Copper | |
| Caesium | |
| Chlorine | |
| Chromium | |

.....

..... **(2 marks)**

**(c)** Iron is a transition element. An atom of iron has the symbol $^{56}_{26}Fe$

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

.....

.....

..... **(3 marks)**

**(d)** Iron reacts with oxygen to form iron(II) oxide.

Complete the balanced symbol equation for this reaction.

$$\_\_ Fe + O_2 \rightarrow \_\_ FeO$$

.....

..... **(2 marks)**

**2 (a)** Manganese is a typical transition element

Which of the following properties would you expect manganese to have.

Tick (✓) **four** boxes.

| **Property** | |
|---|---|
| Low melting point | |
| Useful as a catalyst | |
| Only forms a 1+ ion | |
| Dull | |
| Soft | |
| Good conductor of heat and electricity | |
| Low density | |
| Brittle | |
| Forms coloured compounds | |
| Strong | |

**(4 marks)**

**(b)** Sodium is a Group 1 metal.

Which of the following properties would you expect sodium and manganese to both have.

Tick (✓) **one** box.

| Property | |
|---|---|
| Low melting point | |
| Useful as a catalyst | |
| Only forms a 1+ ion | |
| Dull | |
| Soft | |
| Good conductor of heat and electricity | |
| Low density | |
| Brittle | |
| Forms coloured compounds | |
| Strong | |

**(1 mark)**

**(c)** Give two properties listed in the table in part a) that sodium would have but manganese would not.

.....

.....

**(2 marks)**

**3 (a)** Transition elements and their compounds have many different uses.

Draw a ring around the correct words to complete the sentences.

Gold is used in jewellery because it

| |
|---|
| conducts electricity. |
| is dull. |
| does not react with air. |

Copper is used in wiring because it

| |
|---|
| conducts electricity. |
| is dull. |
| does not react with air. |

Cobalt oxide is added to glazes in pottery as it

| |
|---|
| is a catalyst. |
| is a coloured compound. |
| conducts electricity. |

Iron is used to build bridges because it

| |
|---|
| is strong. |
| is brittle. |
| conducts electricity. |

**(4 marks)**

**(b)** Transition elements and alkali metals are all metals that have some differing properties.

Draw **one** line from each property to the metal it relates to.

| Property | Metal |
| --- | --- |
| Tarnishes quickly in air | |
| High melting point | Transition element |
| High density | |
| Can be cut with a knife | Alkali metal |
| Reacts vigorously with water | |

**(3 marks)**

**(c)** Which of the following metals would be most suitable as a catalyst?

Tick (✓) **one** box.

| | |
| --- | --- |
| Sodium | |
| Nickel | |
| Calcium | |
| Aluminium | |

**(1 mark)**

**4 (a)** Copper is a useful transition element.

What properties of copper make it suitable to make pipes that carry water, for example, in central heating systems.

Tick (✓) **two** boxes.

| | |
|---|---|
| It conducts electricity | |
| It can be bent and shaped | |
| It conducts heat | |
| It is reddish-brown in appearance | |
| It does not react with water | |

.....

..... **(2 marks)**

**(b)** Copper can be alloyed with zinc to make brass.

Brass is used to make musical instruments.

Explain why brass is more suitable for making musical instruments than copper?

.....

..... **(2 marks)**

**(c)** Copper reacts slowly with oxygen in the air to form copper oxide.

Complete the word equation for this reaction.

_____ + oxygen → _____

.....

**(1 mark)**

**(d)** Copper can form copper(I) ions, $Cu^{+}$ and copper(II) ions, $Cu^{2+}$.

What would the formula be of copper(I) oxide?

Tick (✓) **one** box.

| | |
|---|---|
| CuO | |
| $Cu_2O$ | |
| $CuO_2$ | |
| $Cu_2O_2$ | |

.....

**(1 mark)**

**(e)** Copper doesn't react with most dilute acids but it can react with dilute nitric acid.

What is the name of the salt produced when copper reacts with nitric acid?

.....

**(1 mark)**

# Medium Questions

**1 (a)** Iron is a transition metal and is one of the most widely used metals.

Name two physical properties that iron shares with all metals.

.....

..... **(2 marks)**

**(b)** Complete **and** balance the equation for the reaction of iron with hydrochloric acid

$$\_\_Fe + \_\_HCl \rightarrow \_\_\_\_\_ + H_2$$

.....

..... **(2 marks)**

**(c)** Francium lies at the bottom of Group 1 on the Periodic Table and is the most reactive member of the alkali metals.

Explain why it is the most reactive, referring to its electronic structure.

.....

.....

..... **(3 marks)**

**(d)** The properties of the transition elements are different from the elements in Group 1.

State **three** of these different properties of transition elements.

.....

.....

..... **(3 marks)**

**2** Transition metals are located in the middle of the periodic table and have certain properties.

Which two properties do most transition metals have?

| | **Property 1** | **Property 2** |
|---|---|---|
| **A** | soft | form colourless compounds |
| **B** | high melting points | low densities |
| **C** | high densities | form coloured compounds |
| **D** | form ions with multiple charges | do not conduct electricity |

**(1 mark)**

**3** Nitrogen and water are produced when ammonia reacts with oxygen.

A metal oxide catalyst is used to speed up the rate of reaction.

Which of the following metal oxides would most likely be used for this reaction?

**A.** $Na_2O$

**B.** $Li_2O$

**C.** $Al_2O_3$

**D.** $Cr_2O_3$

**(1 mark)**

**4 (a)** An atom of titanium has the symbol, $^{48}_{22}Ti$

Write down the number of protons, neutrons and electrons in this atom.

Protons _____

Neutrons _____

Electrons _____

.....

.....

..... **(3 marks)**

**(b)** Using the Periodic Table, state why titanium is referred to as a transition element.

..... **(1 mark)**

**(c)** Explain why titanium is a good conductor of electricity.

.....

..... **(2 marks)**

**5 (a)** Rhodium is a typical transition metal.

Place a tick (✔) next to each of the **four** properties in the table that you would expect for rhodium.

| **Property** | |
|---|---|
| strong | |
| reactive | |
| low boiling point | |
| forms coloured compounds | |
| high melting point | |
| dull | |
| brittle | |
| conducts heat | |

**(4 marks)**

**(b)** Rhodium is used in the production of alloys and in ornaments and jewellery although its main use is in the automotive industry.

It is used in the exhaust systems where it changes harmful unburned hydrocarbons, carbon monoxide, and nitrogen oxide emissions into less toxic gases.

Suggest **two** properties of rhodium that allows it to be used in this way.

.....

.....

**(2 marks)**

**6** A catalyst is used during the Haber Process to manufacture ammonia.

Which elements are usually used as catalysts?

**A.** The transition metals

**B.** The alkali metals

**C.** The noble gases

**D.** The halogens

**(1 mark)**

**7** Nickel is a transition metal.

Sodium is a Group 1 metal.

Which statement below is correct when comparing their properties?

**A.** Group 1 metals are less reactive than transition metals

**B.** Group 1 metals are harder than transition metals

**C.** Transition metals have lower melting points than Group 1 metals

**D.** Transition metals are more dense than Group 1 metals

**(1 mark)**

**8** Which combination of properties makes transition metals suitable for use in cutting tools?

| | Property 1 | Property 2 |
|---|---|---|
| **A** | malleable | hard |
| **B** | strong | ductile |
| **C** | not reactive | high melting point |
| **D** | high boiling point | conducts electricity |

**(1 mark)**

**9 (a)** What is the name used to describe the block of elements in the middle of the Periodic Table?

.....

**(1 mark)**

**(b)** Vanadium is a transition metal. Some of its properties are listed below:

- It has a high melting point.
- It is a good conductor of heat and electricity.
- It forms coloured compounds.
- It forms crystalline compounds.
- Its compounds can act as catalysts.

From the list, identify the **two** properties that are most characteristic of transition metals and help to distinguish them from main group metals (like those in Group 1 or 2).

.....

.....

**(2 marks)**

**10 (a)** The transition elements have certain properties which make them very useful.

Why is copper used to produce electrical wiring?

.....

.....

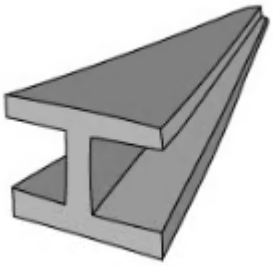
**(2 marks)**

**(b)** State why their compounds are used in glazing pottery.

.....

**(1 mark)**

**(c)** Why is iron used in the construction industry as girders in buildings?



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**(1 mark)**

# Hard Questions

**1 (a)** Vanadium reacts with excess oxygen to form vanadium(III) oxide.

Write the balanced symbol equation for the reaction.

.....

.....

..... **(3 marks)**

**(b)** Vanadium(III) ions can be reduced to vanadium(II) ions.

In terms of electrons, what does reduction mean?

..... **(1 mark)**

**(c)** Write the half equation to show the reduction of vanadium(III) ions to vanadium(II) ions.

.....

..... **(2 marks)**

**(d)** Describe the structure and bonding in vanadium.

.....

.....

..... **(3 marks)**

**2 (a)** Nickel has been used in making the electrodes in spark plugs in car engines for many years. Spark plugs are responsible for igniting the fuel in the combustion engine.

The material the electrodes are made of need to be able to withstand the very high temperatures and corrosive atmosphere found in the car engine and also be able to conduct electricity.

More recently, platinum has been used to make the electrode in spark plugs.

**Table 1** shows some information about nickel and platinum.

**Table 1**

| | **Nickel** | **Platinum** |
|---|---|---|
| **Melting point in $^{o}C$** | 1455 | 1769 |
| **Boiling point in $^{o}C$** | 2920 | 4107 |
| **Cost in £ per kg** | 22 | 25,058 |
| **Approximate lifetime in km** | 30,000 | 70,000 |
| **Efficiency** | Reduces rapidly, petrol is not burnt completely | More efficient, petrol is burnt completely for much longer |
| **Relative reactivity** | More reactive than gold | Less reactive than gold |

Evaluate the use of nickel and platinum for making the electrodes in spark plugs.

You should refer to the information in **Table 1** and your knowledge about the properties of these metals in your answer.

.....

**(6 marks)**

**(b)** Spark plugs with iridium electrodes are also available. They can last 25% longer than platinum spark plugs.

Iridium is six times harder than platinum with a melting point 700 $^{o}$C higher.

Suggest **one** other property of iridium.

**(1 mark)**

**(c)** Platinum, palladium and rhodium are all used within a catalytic convertor to remove harmful gases from the car's exhaust.

The catalytic convertor consists of a honeycomb structure which is coated with the metals. The exhaust gases travel through the catalytic convertor before leaving the vehicle.

Suggest why the convertor has a honeycomb structure.

Explain your answer.

**(2 marks)**

**(d)** **Table 2** shows the amount of metals used in a catalytic convertor and the cost of each metal.

**Table 2**

| Metal | Platinum | Palladium | Rhodium |
|---|---|---|---|
| **Mass of metal used in catalytic convertor in grams** | 5.8 | 4.5 | 2.1 |
| **Cost of metal in £ per gram** | 25.06 | 48.32 | 363.27 |

What is the total cost of the three metals used in the catalytic convertor?

Give your answer to the nearest pound.

.....

.....

..... **(3 marks)**

**3 (a)** The transition elements are metals which are found in the central section of the periodic table.

Group 1 elements are also metals.

**Table 1** shows the melting point and oxide formulae of two elements from Group 1 and two transition elements

**Table 1**

| | **Lithium** | **Rubidium** | **Chromium** | **Cobalt** |
|---|---|---|---|---|
| **Melting point in °C** | 180 | 39 | 1857 | 1535 |
| **Formula of oxides** | $Li_2O$ | $Rb_2O$ | $CrO$<br>$Cr_2O_3$<br>$CrO_2$<br>$CrO_3$ | $CoO$<br>$Co_2O_3$<br>$Co_3O_4$ |

Use the data from **Table 1** and your knowledge of Group 1 metals and transition metals to compare their chemical and physical properties.

**(6 marks)**

**(b)** Iron is another transition metal. When it reacts with oxygen, it can form different compounds which contain the $Fe^{2+}$ ion or the $Fe^{3+}$ ion.

Complete the two balanced symbol equations for the reaction between iron and oxygen to show how the different compounds are formed.

Formation of compound containing $Fe^{2+}$ ions:

$$\_\_ Fe + \_\_ O_2 \rightarrow \_\_\_\_\_$$

Formation of compound containing $Fe^{3+}$ ions:

$$\_\_ Fe + \_\_ O_2 \rightarrow \_\_\_\_\_$$

**(4 marks)**

**(c)** Sodium hydroxide was added to one solution containing $Fe^{2+}$ ions and another solution containing $Fe^{3+}$.

What observations would be made?

Observations with sodium hydroxide and solution containing $Fe^{2+}$ ions:

_____

Observations with sodium hydroxide and solution containing $Fe^{3+}$ ions:

_____

.....

..... **(2 marks)**

**(d)** Iron can be used to displace copper from a solution of copper(II) sulfate.

Iron(II) sulfate is also formed. The equation for this reaction is:

$$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$$

Identify which species has been oxidised and which has been reduced.

You should include the ionic equation for the reaction and the two half equations in your answer.

.....

**(5 marks)**

**4 (a)** Manganese can form compounds which are black, brown, pink, red, green, blue, and purple.

Why does manganese form different coloured compounds?

.....

**(1 mark)**

**(b)** A compound of manganese, manganese dioxide, has the formula, $MnO_2$.

What is the charge on the manganese ion is manganese dioxide?

.....

**(1 mark)**

**(c)** Manganese dioxide acts as a catalyst in the decomposition of hydrogen peroxide.

A student made the following statements about the role of manganese dioxide in this reaction:

"Manganese dioxide increases the rate of reaction by providing an alternative reaction pathway which has a lower activation energy.

The yield of oxygen produced increases as more oxygen can be produced in a given amount of time".

Is the student correct?

Explain your answer.

.....

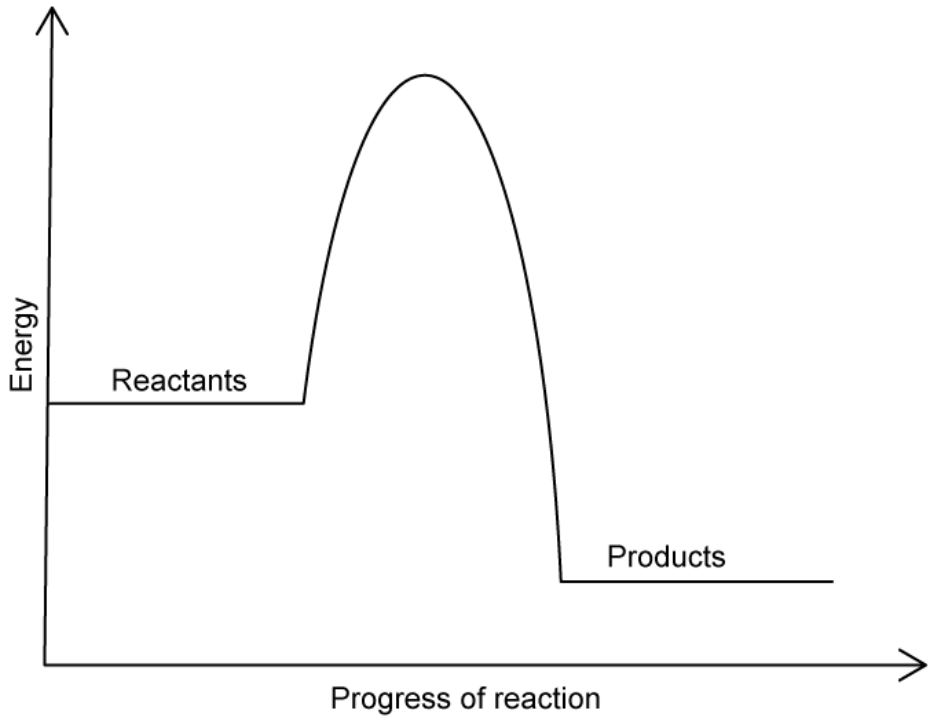
.....

.....

**(3 marks)**

**(d)** The diagram shows the reaction profile for the decomposition of hydrogen peroxide with a catalyst.

**Figure 1**




On **Figure 1**:

- Draw the reaction profile for the reaction without a catalyst
- Draw and label an arrow to show the activation energy for the reaction with a catalyst

**(2 marks)**