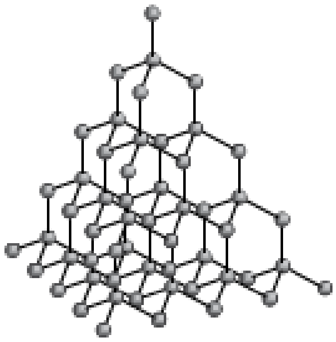
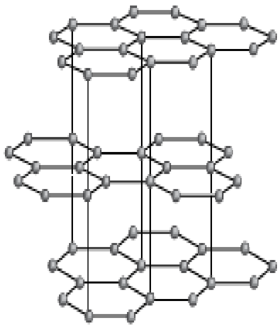
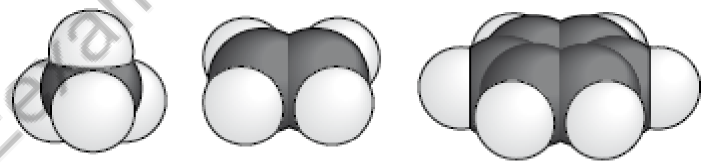



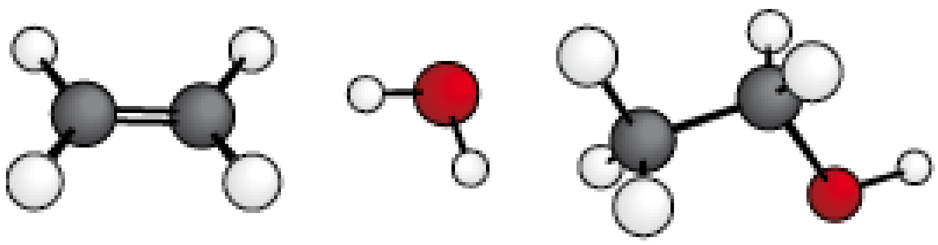
CHEMISTRY

0620



Chapter 9

The Periodic Table



Name: ________________

Chapter 9: The Periodic Table

- Early attempts to explain periodic patterns (regularly repeating variations) in the properties of the known elements were based on their relative atomic masses. The <u>modern Periodic table</u> is based on the elements in order of their atomic numbers. ∴The Periodic table is a way of classifying the elements.

- A **group** in the Periodic Table contains elements with the same outer-shell electronic configuration but very different atomic numbers; the elements and their compounds have many similar chemical properties.

- All elements in a group have
  - ➢ same number of electrons in the outer shell
  - ➢ similar outer shell electronic configuration

- **Periods** in the Periodic Table are sequences of elements whose outermost electrons are in the same shell. Neighbouring members differ by one proton and one electron.

Group	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**0**
Element	sodium	magnesium	aluminium	silicon	phosphorus	sulfur	chlorine	argon
Valency electrons	1	2	3	4	5	6	7	8
Nature of element	metal			metalloid	non-metal			
Melting point/ °C	98	649	660	1410	590	119	-101	-189
Boiling point/ °C	883	1107	2467	2355	ignites	445	-35	-186
Acid/base nature of oxide	basic		amphoteric	acidic				-
Valency shown in compound	1 (NaC*l*)	2 (MgC*l*$_2$)	3 (A*l*C*l*$_3$)	4 (SiC*l*$_4$)	3 (PH_3)	2 (H_2S)	1 (HC*l*)	-

- The elements in a period do not have similar properties. In fact, there is a trend (gradual change) from **metal to non-metal** properties along the period, from left to right.

- The **zig-zag line** separates the metals from the non-metals, with the metals on the left.

- Silicon is called **metalloid** because it acts as a metal in some ways and as a non-metal in others.

- There are metalloids in all the periods of the table. They (boron, silicon, germanium, arsenic, antimony, tellurium and polonium) lie along the zig-zag line that separates metals from non-metals.

- Metals conduct electricity. Metalloids can too, under certain conditions. So they are called **semi-conductors**. This leads to their use in computer chips and PV cells for solar power. Silicon is used the most.

- Silicon occurs naturally in sand as silica (silicon dioxide). To extract it the silica is heated with carbon (coke).

- Melting and boiling points rise to the middle of the period, then fall to very low values on the right. Only chlorine and argon are gases at room temperature.

- The oxides of the metals are **basic** – they react with acids to form salts. Those of the non-metals are **acidic** – they react with alkalis to form salts.

- Aluminium oxide is an **amphoteric** oxide because it reacts with both acids and alkalis to form salts.

- The **valency of an element** is the number of electrons its atoms lose, gain or share, to form a compound.

- Note that *valency* is not the same as *the number of valency electrons*. But:

    - the valency does match the number of valency electrons, up to Group IV

    - the valency matches the charge on the ion, where an element forms ions.

- **Reactivity** *decreases* across the metals. Aluminium is a lot less reactive than sodium because the more electrons a metal atom needs to lose, the more difficult it is. The electrons must have enough energy to overcome the pull of the nucleus.

- **Reactivity** *increases* across the non-metals. Chlorine is more reactive than sulfur because the fewer electrons a non-metal atom needs to gain, the easier it is to attract them.

- **Hydrogen** sits alone in the Periodic Table because it has one outer electron and forms a positive ion (H^+) like Group I metals – but unlike them it is a gas and usually reacts like a non-metal.

- Some of the elements in the Periodic Table are artificial: they have been created in the lab. Most of these are in the lowest block. They include neptunium (Np) to lawrencium (Lr) in the bottom row. These **artificial elements** are radioactive, and their atoms break down very quickly. (That is why they are not found in nature).

- The group number is the same as the number of **valency (outer-shell) electrons** - except for Group 0.

- The **noble gases** are not called Group 8 but Group 0.

- The Group 0 elements are all non-metals. They are colourless gases which occur naturally in air and exist as single atoms (**monoatomic**).

- The density and boiling points increase on descending the group.

- The gases grow denser (or 'heavier') down the group because the mass of atoms increases. The increase in boiling points is a sign of increasing attraction between atoms.

- The atoms of Group 0 elements have a very stable arrangement of electrons in their outer shells. This makes them **unreactive** or **inert**.

- The unreactivity of the noble gases makes them very useful. For example:

  - **Helium** is used in balloons and airships because it is lighter than air and non-flammable.

  - **Argon** is used to provide an inert atmosphere, for example in welding and in tungsten light bulbs. Argon will protect metals that are being welded. Argon won't react with hot metals unlike oxygen in air. If air were used as the filler in light bulbs, the oxygen in it would make the tungsten filament burn away.

  - **Neon** is used in advertising sign. It grows red, but the colour can be changed by mixing it with other gases.

  - **Krypton** is used in laser – for example for eye surgery and in car headlamps.

- **Xenon** gives a light like bright daylight, but with a blue tinge. It is used in lighthouse lamps, lights for hospital operating rooms and car headlamps.

- The elements of Group I are often called the **alkaline metals**.

- The Group I elements lithium to francium are metals, but compared to most metals:
  - they are much softer (all can be cut with a knife)
  - they are lighter – they have low density (lithium, sodium and potassium float on water)
  - they have much lower melting and boiling points
  - they are much more reactive.

- **Physical properties trends** when **go down Group I**
  - atomic radius increases
  - ionic radius increases
  - softness increases
  - density increases
  - melting point & boiling point decreases
  - as a reducing agent (reducing strength) increases and thus reactivity increases.

- The strength of metallic bond $\alpha \ \dfrac{\text{number of delocalise electrons}}{\text{ionic radius of metal cation}}$

- The Group I elements ***react with water*** to produce hydrogen gas and the alkali metal hydroxide.

- The reactivity of Group I elements with water increases down the group. Assuming M is the metal atom, the general equation is:

$$2M(s) + 2H_2O(l) \rightarrow 2MOH(s) + H_2(g)$$

- The alkali metals react vigorously with water. Hydrogen bubbles off, leaving solutions of their hydroxides, which are alkalis.

- The Group I elements ***react with chlorine*** to produce metal chloride. For example: heated sodium burn brightly in chlorine forming sodium chloride.

- The Group I elements ***react with oxygen*** to produce metal oxide which dissolve in water to give alkaline solution. For example: heated sodium burn fiercely in oxygen to form sodium oxide.

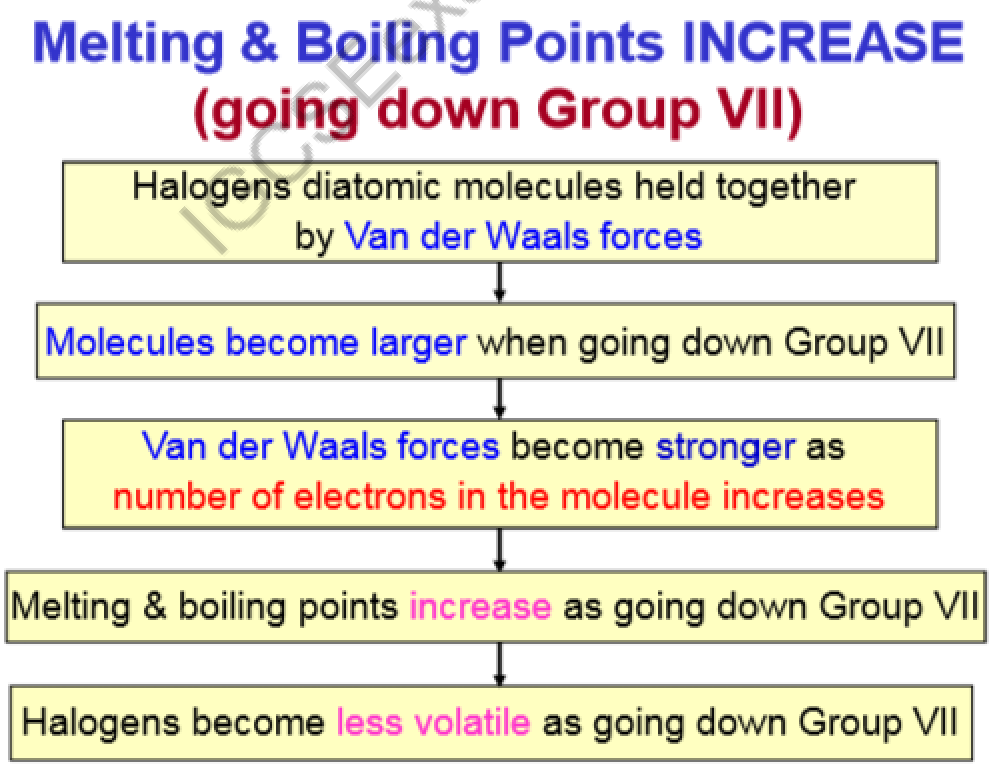
- **Reactivity** of Group I elements with chlorine and oxygen **increases down the group**.

- The alkali metals are the <u>most reactive of all the metals</u> because they need to lose only one electron to gain a stable outer shell.

- In reaction, the Group I atoms lose their outer electron to gain a stable outer shell. The more shells there are, the further the outer electron is from the positive nucleus – so the easier to lose.

- The alkali metals **form ionic compounds**, in which the metal ion has a charge of 1+. The compounds are white solids. They dissolve in water to give colourless solutions.

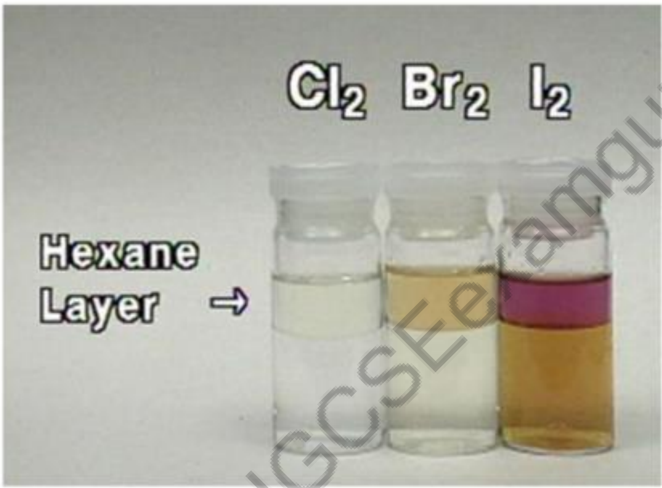
- The **halogens** chlorine, bromine and iodine are covalent <u>diatomic molecules</u> at room temperature. They become increasingly less volatile and more deeply coloured on descending Group VII. Their boiling points increase as van der Waals' forces increase going down the group.



- Fluorine is a pale yellow gas; chlorine is a greenish yellow gas; bromine is a dark red liquid giving off a dense red-orange vapour; iodine is a shiny, grey-black crystalline solid which sublimes (changes directly from a solid to a gas) to a purple vapour.

- The halogens are more soluble in organic solvents than in aqueous solution. Iodine is purple in cyclohexane, bromine is a strong orange-yellow colour and chlorine is pale yellow.

Halogen	Gaseous state	Water	CCl_4
Chlorine, Cl	Greenish-yellow	Pale yellow-green	Pale yellow-green
Bromine, Br	Reddish-brown	Reddish-brown	Reddish-brown
Iodine, I	Purple	Brownish-orange	Violet



Hexane forms a layer on top of water.

Colour of dissolved halogen in hexane:

- Chlorine – pale green
- Bromine – orange
- Iodine – purple

Molecule X_2	MP (°C)	BP (°C)	Physical State at room conditions	Solubility in water
$F_{2\,(g)}$	-220	-188	Pale yellow gas	Soluble
$Cl_{2\,(g)}$	-101	-35	Greenish yellow gas	Moderately soluble
$Br_{2\,(l)}$	-7	59	Reddish brown Liquid	Slightly soluble
$I_{2\,(s)}$	114	184	Black Solid, purple vapour (Sublimes)	Insoluble

MP = melting point ;
BP = boiling point

- Solubility of the elements in water decreases as X_2 molecules become larger.

$$\underset{\text{Halogen}}{X_2} + H_2O \leftrightarrow \underset{\text{Hydrogen halide}}{HX} + \underset{\text{Hypohalous acid}}{HOX}$$

- Iodine is insoluble in water but soluble in KI solution. Aqueous iodine is reddish-brown solution.

- Cl_2 is moderately soluble in water. Cl_2 water turns litmus paper red and then bleaches it.

$$Cl_2(g) + H_2O(l) \rightarrow HCl(aq) + HClO(aq)$$

- The **general properties** of the Group VII elements chlorine, bromine and iodine are as follows:
  - they are all non-metals
  - they all exist as diatomic molecules at room temperature
  - their melting and boiling points increase with increasing atomic number
  - the colour of the elements deepens with increasing atomic number
  - the density increases on descending the group
  - in compounds a halogen atom increases its number of electrons in the outer shell from seven to eight by ionic or covalent bonding
  - the reactivity of the elements decreases on descending the group
  - they exhibit a range of oxidation states
  - the electronegativity of the elements decreases on descending the group
  - their oxidising ability decreases on descending the group.

- The order of reactivity can be determined by **displacement reactions**. A more reactive halogen can displace a less reactive halogen from a solution of one of its salts (Each halide ion can be oxidised by the halogen **above** it in Group).

- Chlorine displaces bromine and iodine:

$$Cl_2(aq) + \underset{\text{colourless}}{2KBr(aq)} \rightarrow 2KCl(aq) + \underset{\text{orange}}{Br_2(aq)}$$

Or $Cl_2(aq) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(aq)$

$Cl_2(aq) + 2KI(aq) \rightarrow 2KCl(aq) + I_2(aq)$

colourless red-brown

Or $Cl_2(aq) + 2I^-(aq) \rightarrow 2Cl^-(aq) + I_2(aq)$

- Bromine displaces iodine:

$Br_2(aq) + 2KI(aq) \rightarrow 2KBr(aq) + I_2(aq)$

colourless red-brown

Or $Br_2(aq) + 2I^-(aq) \rightarrow 2Br^-(aq) + I_2(aq)$

- Iodine does not displace either chlorine or bromine.

Halogen	Halide ion		
	Chloride, Cl^-	Bromide, Br^-	Iodide, I^-
Chlorine, Cl_2	×	orange-yellow bromine released	purple iodine released
Bromine, Br_2	no reaction	×	purple iodine released
Iodine, I_2	no reaction	no reaction	×

- These reactions show that, of the three halogens:
  - Chlorine is the **most** reactive; it **displaces** both bromine and iodine from their compounds.
  - Iodine is the **least** reactive, it does not displace either of the others from their compounds.

- ∴ **A Halogen will displace a less reactive halogen from a solution of its halide.**

- The **transition elements** are the block of 30 elements in the middle of the Periodic Table.

Transition element	chromium	manganese	iron	cobalt	nickel	copper
Symbol	Cr	Mn	Fe	Co	Ni	Cu
Appearance	metallic silver	metallic silver	metallic grey	metallic grey	metallic silver	metallic bronze

- Transition elements are much **less reactive** than the Group I metals. For example copper and nickel do not react with water, or catch fire in air – unlike sodium. In general, the transition elements do not corrode readily in atmosphere. But iron is an exception – it rusts easily.

- Transition elements show **no clear trend in reactivity**, unlike the group I metals.

- Most transition elements **form coloured compounds**. In contrast, the group I metals form white compounds.

- Most transition elements can form **ions with different charges** and hence they show **variable valency**.

- Transition elements can **form more than one compound with another element**. For example: oxide of copper and oxide of iron.

  copper(I) oxide, Cu_2O & copper(II) oxide, CuO
  iron(II) oxide, FeO & iron(III) oxide, Fe_2O_3

- The Roman numeral in brackets indicates how many electrons the metal atom has lost and this number is called its **oxidation state**.

- Most transition elements can **form complex ions**. For example: deep blue colour of $[Cu(H_2O)_2(NH_3)_4]^{2+}$.

- The transition elements are metals with similar physical and chemical properties.

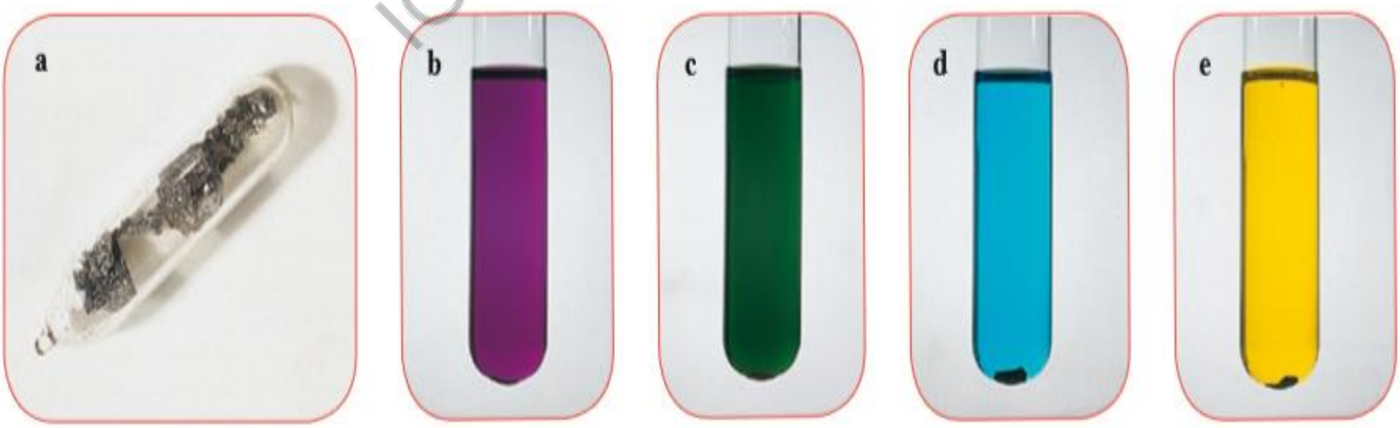
- The **physical properties** of transition elements are:
  - they are hard, tough and strong
  - they have high density
  - they have high melting points
  - they are ductile (can be drawn into wires) and malleable (can be knocked/hammered into different shapes)
  - they are good conductors of heat and electricity.

- They also have certain **chemical properties** in common:
  - they can show several different oxidation states in their compounds
  - they are good catalysts
  - they form coloured compounds
  - they form complexes with ligands

- Transition elements can exist in **several oxidation states** and **often coloured**

Element	Oxidation states						
Sc			+3				
Ti		+2	+3	+4			
V		+2	+3	+4	+5		
Cr		+2	+3	+4	+5	+6	
Mn		+2	+3	+4	+5	+6	+7
Fe		+2	+3	+4	+5	+6	
Co		+2	+3	+4	+5		
Ni		+2	+3	+4			
Cu	+1	+2	+3				
Zn		+2					

- The following diagrams show vanadium and its oxidation states: **a** vanadium metal (silvery); **b** a solution containing V^{2+} ions (violet); **c** a solution containing V^{3+} ions (green); **d** a solution containing VO^{2+} ions (blue); **e** a solution containing VO_2^+ ions (yellow).



- A **catalyst** is a substance that speeds up a chemical reaction, without itself being permanently changed in a chemical way. Many transition elements are effective catalysts, and are used in reactions both in the laboratory and in industry.

- In the laboratory, you may have seen the decomposition of hydrogen peroxide to water and oxygen:

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

At room temperature this reaction is very slow. However, if **manganese(IV) oxide** is added it acts as a catalyst, and the reaction becomes very rapid.

- In industry, one of the best-known reactions that depends on a catalyst is the **Haber process**, in which nitrogen and hydrogen react to give ammonia:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The catalyst used in this reaction is finely divided **iron**.

- ∴ Transition elements are good catalysts because they can transfer electrons easily and provide a site for the reaction to take place.

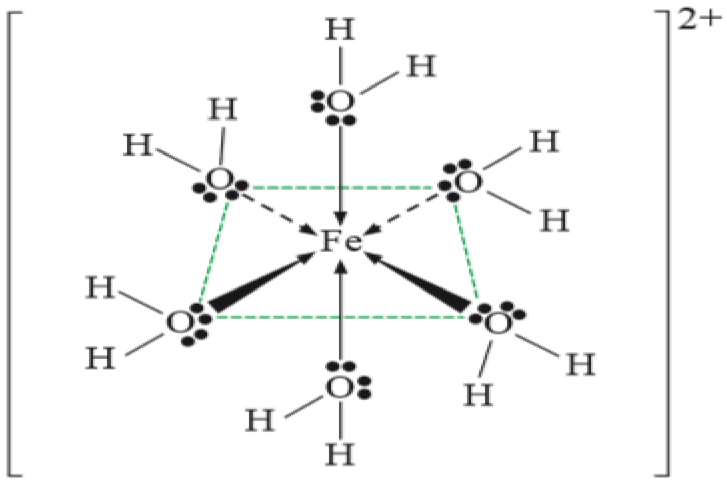
- Transition metal ions <u>in aqueous solution</u> are frequently **coloured**.

Ti^{3+}	purple
Cr^{3+}	violet (or green)
Mn^{2+}	pink
Fe^{2+}	green
Fe^{3+}	yellow
Co^{2+}	pink
Ni^{2+}	green
Cu^{2+}	blue

- Transition elements **form complexes** by combining with ligands.

- Transition element ions such as Fe^{2+} ions in aqueous solution form a special association with water molecules. Six water molecules can each donate one lone-pair to an Fe^{2+} ion, forming dative or coordinate bonds to it.

- The Fe^{2+} ion and its six bonded water molecules are called a **complex ion**. The ion is written **$[Fe(H_2O)_6]^{2+}$**.



- ∴ A **<u>complex ion</u>** consists of a central metal ion with one or more negative ions or neutral molecules coordinately bonded to it.

- Transition elements react with aqueous hydroxide ions to give precipitates. Therefore the colour of the precipitate can be used to identify the transition metal ion.

- When aqueous sodium hydroxide is added to a solution of a transition metal ion, a precipitate of the transition metal hydroxide is formed. These precipitates resemble a jelly and so are called 'gelatinous', and their colour can identify the transition metal ion.

$$Cu^{2+}(aq) + 2OH^-(aq) \longrightarrow \underset{\text{pale blue}}{Cu(OH)_2(s)}$$

$$Fe^{2+}(aq) + 2OH^-(aq) \longrightarrow \underset{\text{green}}{Fe(OH)_2(s)}$$

$$Fe^{3+}(aq) + 3OH^-(aq) \longrightarrow \underset{\text{rust}}{Fe(OH)_3(s)}$$

$$Mn^{2+}(aq) + 2OH^-(aq) \longrightarrow \underset{\text{cream}}{Mn(OH)_2(s)}$$

$$Cr^{3+}(aq) + 3OH^-(aq) \longrightarrow \underset{\text{grey-green}}{Cr(OH)_3(s)}$$

$$Co^{2+}(aq) + 2OH^-(aq) \longrightarrow \underset{\text{blue-green}}{Co(OH)_2(s)}$$

- Note that gelatinous precipitates can also be formed when ammonia solution is added to the aqueous transition element ion. This is because ammonia is a weak base that exists in equilibrium with ammonium hydroxide in aqueous solution:

$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

- This means that aqueous ammonia is a source of hydroxide ions. For example, aqueous ammonia added to $Mn^{2+}(aq)$ gives a cream precipitate of $Mn(OH)_2$.

- The oxides and hydroxides of all the metals are bases; they react with acids to form salts. Therefore, salts of transition elements can be made by starting with their oxides or hydroxides, and reacting these with acids.

- Transition metals have a variety of different oxidation states and so they can be readily oxidised or reduced. Their redox reactions are an important part of their chemistry, especially as they are used in titrations for many different types of analysis.

- There are many **redox reactions** involving transition metal ions. For example, the reaction between iron(II) ions (Fe^{2+}) and manganate(VII) ions (MnO_4^-) in acidified aqueous solution. The equation for this reaction:

$$5Fe^{2+} + \underset{\text{purple}}{MnO_4^-} + 8H^+ \longrightarrow \underset{\text{pale pink}}{Mn^{2+}} + 5Fe^{3+} + 4H_2O$$

- This type of redox equation can be constructed from **two half-equations**:
  - ➢ the half-equation showing oxidation of Fe(II) in Fe^{2+} to Fe(III) in Fe^{3+}:

    $Fe^{2+} \rightarrow Fe^{3+} + e^-$

  - ➢ the half-equation showing reduction of Mn(VII) in MnO_4^- to Mn(II) in Mn^{2+} in the presence of acid:

    $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

- To construct the final equation, write the two half equations so that the **number of electrons** in each is the **same**. This means the first half-equation is multiplied by 5. Then the half-equations can be added together and the electrons on each side of the arrow cancel:

$$5Fe^{2+} \longrightarrow 5Fe^{3+} + 5e^-$$

$$+ \quad MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$$

$$5Fe^{2+} + MnO_4^- + 8H^+ \longrightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

- Any two half-equations can be used in this way to construct a redox equation. Another example is the reaction between aqueous Fe^{2+} ions and hydrogen peroxide, H_2O_2.

- The Fe^{2+} ions are oxidised to Fe^{3+} ions, and the hydrogen peroxide is reduced to water:

  $$Fe^{2+} \rightarrow Fe^{3+} + e^-$$

  $$H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$$

  This time the top half-equation is multiplied throughout by 2. The final redox equation is:

  $$2Fe^{2+} + H_2O_2 + 2H^+ \rightarrow 2Fe^{3+} + 2H_2O$$

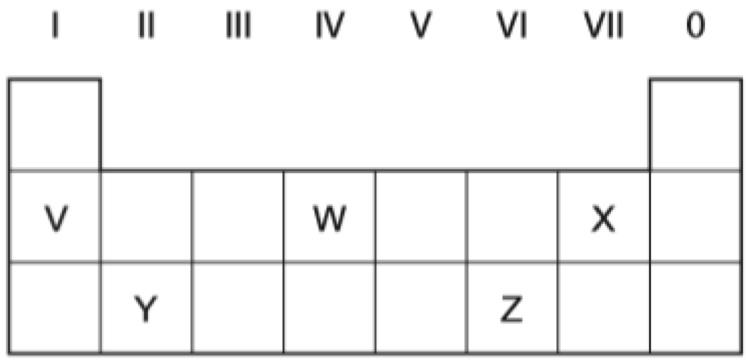
- The hard, strong transition elements are used in structures such as bridges, buildings and cars. Iron is the most widely used – usually in the form of **alloys** called **steels**. In alloys, small amounts of other substances are mixed with a metal to improve its properties.

- Many transition elements are used in making alloys. For example, chromium and nickel are mixed with iron to make **stainless steel**.

- Transition elements are used as conductor of heat and electricity. For example, steel is used for radiators and copper for electric wiring.

Tutorial

1) The diagram shows a section of the Periodic Table.



Which elements will conduct electricity at room temperature?

A V, W and X

B V, Y and W

C W, X and Z

D Y and Z

2) Which statement is correct for the element of proton number 19?

A It is a gas that dissolves in water.

B It is a hard metal that is not very reactive with water.

C It is a non-metal that burns quickly in air.

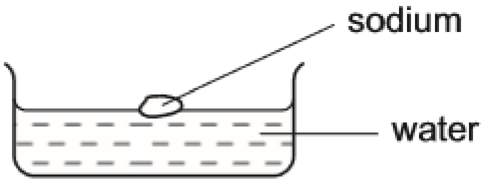
D It is a soft metal that is highly reactive with water.

3) Element X forms an acidic, covalent oxide.

Which row shows how many electrons there could be in the outer shell of an atom of X?

	1	2	6	7
A	✓	✓	✗	✗
B	✓	✗	✓	✗
C	✗	✗	✓	✓
D	✗	✓	✗	✓

4) When sodium reacts with water, a solution and a gas are produced.

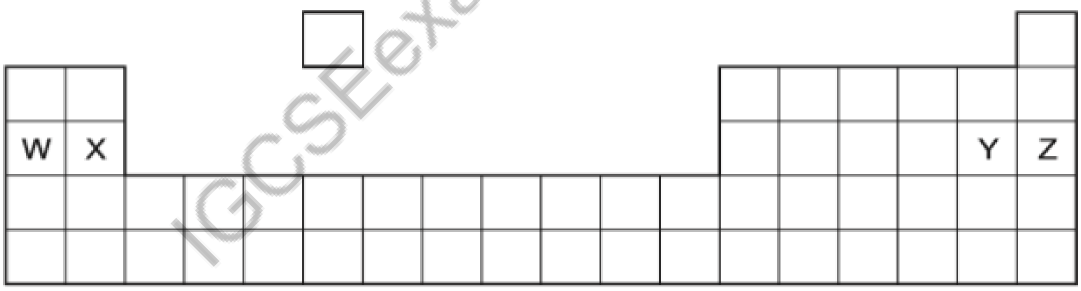


The solution is tested with litmus paper and the gas is tested with a splint.

What happens to the litmus paper and to the splint?

	litmus paper	splint
A	blue to red	glowing splint relights
B	blue to red	lighted splint 'pops'
C	red to blue	glowing splint relights
D	red to blue	lighted splint 'pops'

5) The diagram shows an outline of the Periodic Table.



Which ionic compound could be formed?

A W^+Y^-

B W^+Z^-

C X^+Y^-

D X^+Z^-

6) Five elements have proton numbers 10, 12, 14, 16 and 18.

What are the proton numbers of the three elements that form oxides?

A 10, 12 and 14

B 10, 14 and 18

C 12, 14 and 16

D 14, 16 and 18

7) The element rubidium, Rb, is immediately below potassium in the Periodic Table.

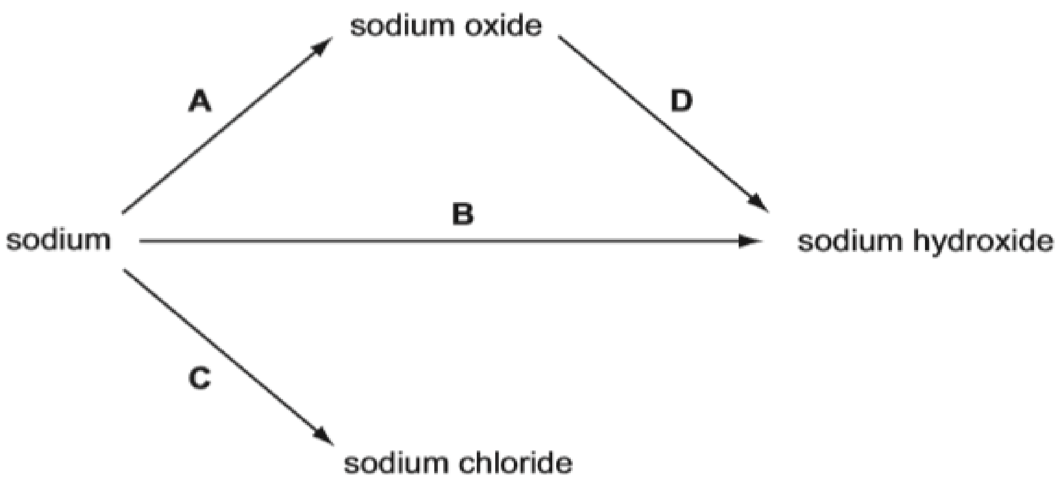
It reacts with bromine to form the compound rubidium bromide.

Which descriptions of this compound are correct?

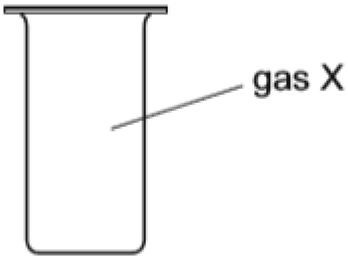
	type of bond	formula	colour
A	covalent	RbBr	brown
B	covalent	$RbBr_2$	white
C	ionic	RbBr	white
D	ionic	$RbBr_2$	brown

8) Some reactions involving sodium are shown.

Which reaction does not involve the formation of a base?



9) X is a monatomic gas.



Which statement about X is correct?

A X burns in air.

B X is coloured.

C X is unreactive.

D X will displace iodine from potassium iodide.

10) Statement 1: Helium is a reactive gas.

Statement 2: Helium can be used to fill balloons.

Which is correct?

A Both statements are correct and statement 2 explains statement 1.

B Both statements are correct but statement 2 does not explain statement 1.

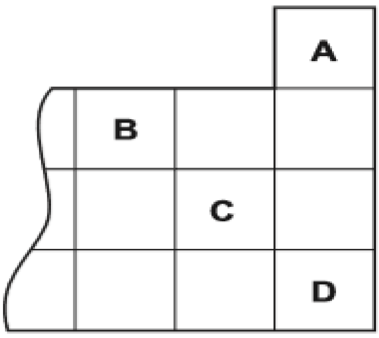
C Statement 1 is correct but statement 2 is incorrect.

D Statement 2 is correct but statement 1 is incorrect.

11) The diagram shows a section of the Periodic Table.

Which element is described below?

'A colourless, unreactive gas that is denser than air.'



12) Why are weather balloons filled with helium rather than hydrogen?

A Helium is found in air.

B Helium is less dense than hydrogen.

C Helium is more dense than hydrogen.

D Helium is unreactive.

13) The equation shows the reaction between a halogen and aqueous bromide ions.

$$\underset{\dots 1 \dots}{X_2} + \underset{\dots 2 \dots}{2Br^-(aq)} \rightarrow 2X^-(aq) + \underset{\dots 3 \dots}{Br_2}$$

Which words correctly complete gaps 1, 2 and 3?

	1	2	3
A	chlorine	brown	colourless
B	chlorine	colourless	brown
C	iodine	brown	colourless
D	iodine	colourless	brown

14) Elements X, Y and Z are in Group VII of the Periodic Table.

X is a gas.

Y is less reactive than Z

Z is a red liquid.

When X, Y and Z are put in order of increasing proton number, which order is correct?

A X → Y → Z

B X → Z → Y

C Y → X → Z

D Y → Z → X

15) The table shows some properties of two elements in Group VII of the Periodic Table.

element	state at 20 °C	density / g per cm^3	melting point / °C
chlorine	gas	0.0032	–101
bromine	liquid	3.1	–7

Which properties is fluorine likely to have?

	state at 20 °C	density / g per cm^3	melting point / °C
A	gas	0.0017	–220
B	gas	0.17	–188
C	liquid	0.0017	–220
D	liquid	0.17	–188

16) Element X is below iodine in the Periodic Table.

Which row correctly shows the physical state of element X at room temperature and its reactivity compared with that of iodine?

	physical state of element X at room temperature	reactivity compared with that of iodine
A	gas	less reactive
B	solid	less reactive
C	gas	more reactive
D	solid	more reactive

17) An element has the following properties.

- It forms coloured compounds.
- It acts as a catalyst.
- It melts at 1539 °C.

In which part of the Periodic Table is the element found?

A Group I

B Group IV

C Group VII

D transition elements

18) Which properties of the element titanium, Ti, can be predicted from its position in the Periodic Table?

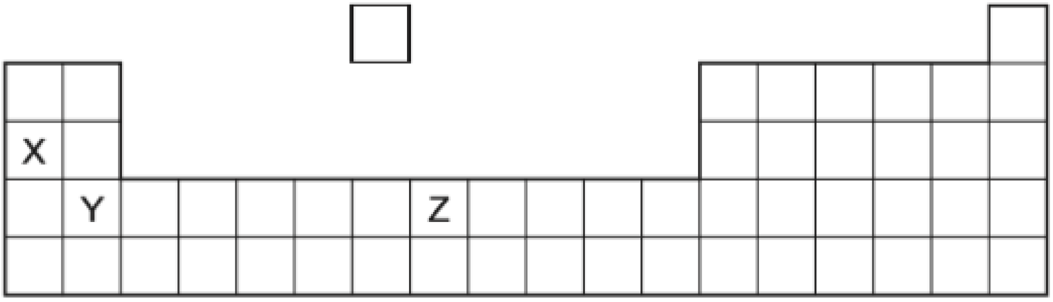
	can be used as a catalyst	conducts electricity when solid	has low density	forms coloured compounds
A	✓	✓	✗	✓
B	✓	✓	✓	✗
C	✓	✗	✓	✓
D	✗	✓	✓	✓

19) The table gives information about four elements.

Which element is a transition metal?

	colour of element	electrical conductivity of element	colour of oxide
A	black	high	colourless
B	colourless	low	white
C	grey	high	red
D	yellow	low	colourless

20) The diagram shows an outline of part of the Periodic Table.



Which statement about elements X, Y and Z is not correct?

A All are metals.

B All conduct electricity.

C All form coloured compounds.

D All react with oxygen.

21) This question is concerned with the following oxides.

sulfur dioxide
carbon monoxide
lithium oxide
aluminium oxide
nitrogen dioxide
strontium oxide

a) Which of the above oxides will react with hydrochloric acid but not with aqueous sodium hydroxide?

b) Which of the above oxides will react with aqueous sodium hydroxide but not with hydrochloric acid?

c) Which of the above oxides will react with both hydrochloric acid and aqueous sodium hydroxide?

d) Which of the above oxides will not react with hydrochloric acid or with aqueous sodium hydroxide?

22) Some properties of the Group I metals are shown in the table.

metal	melting point / °C	hardness	density / g per cm^3
lithium		fairly hard	0.53
sodium	98	fairly soft	
potassium	63	soft	
rubidium	39	very soft	1.53
caesium	29	extremely soft	1.88

a) Estimate the melting point of lithium.

b) How does the hardness of these metals change down the group?

c) Estimate the density of potassium.

23) Choose an element from the list below which best fits the description.

Rb **Fe** **Si** **I** **P** **Sr**

a) An element which reacts with cold water. ....

b) It is a solid at room temperature and exists as diatomic molecules, X_2. ....

c) It can form two oxides, XO and X_2O_3. ....

d) This element has a hydride of the type XH_3. ....

e) It has a macromolecular structure similar to that of carbon. ....

24) Use your copy of the Periodic Table to answer these questions.

a) Choose an element from the Periodic Table to match each description. You may give either the name or the symbol.

i) It is the most reactive metal. ....

ii) It is the only non-metal which is a liquid at r.t.p.. ....

iii) An isotope of this element is used as a fuel in nuclear reactors. ....

iv) This Group VII element is a solid at r.t.p.. ....

v) This element is in Group V and Period 4. ....

vi) This unreactive gas is used to fill lamps. ....

b) Predict the formula of each of the following compounds.

i) germanium oxide
....

ii) tellurium bromide
....

c) Give the formula of each of the following ions.

i) strontium
....

ii) fluoride
....

25) Chlorine is a halogen.

a) State the colour of chlorine.

The table shows some properties of the halogens.

element	boiling point / °C	density in liquid state / g per cm^3	colour
fluorine	–188	1.51	yellow
chlorine	–35	1.56	
bromine	–7		red-brown
iodine	+114	4.93	grey-black

Use the information in the table to answer the following questions.

b) Predict the density of liquid bromine.

c) Describe the trend in boiling point of the halogens down the group.

d) Explain why bromine does not react with aqueous potassium chloride.

26) Nickel is a transition element. Predict three differences in the chemical properties of nickel and barium.

27) Vanadium is a transition element. It has more than one oxidation state. The element and its compounds are often used as catalysts.

a) Complete the electron distribution of vanadium by inserting one number.

2 + 8 + ... + 2

b) Predict three physical properties of vanadium which are typical of transition elements.

28) Predict two differences in physical properties and two differences in chemical properties between rubidium and the transition metal niobium.

DATA SHEET
The Periodic Table of the Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 **H** Hydrogen 1										4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4											11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12											27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	64 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	**Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57 *	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	**Po** Polonium 84	**At** Astatine 85	**Rn** Radon 86
Fr Francium 87	226 **Ra** Radium 88	227 **Ac** Actinium 89 †															

140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	**Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	162 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
232 **Th** Thorium 90	**Pa** Protactinium 91	238 **U** Uranium 92	**Np** Neptunium 93	**Pu** Plutonium 94	**Am** Americium 95	**Cm** Curium 96	**Bk** Berkelium 97	**Cf** Californium 98	**Es** Einsteinium 99	**Fm** Fermium 100	**Md** Mendelevium 101	**No** Nobelium 102	**Lr** Lawrencium 103

*58-71 Lanthanoid series
†90-103 Actinoid series

Key

a **X** b	a = relative atomic mass X = atomic symbol b = proton (atomic) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).