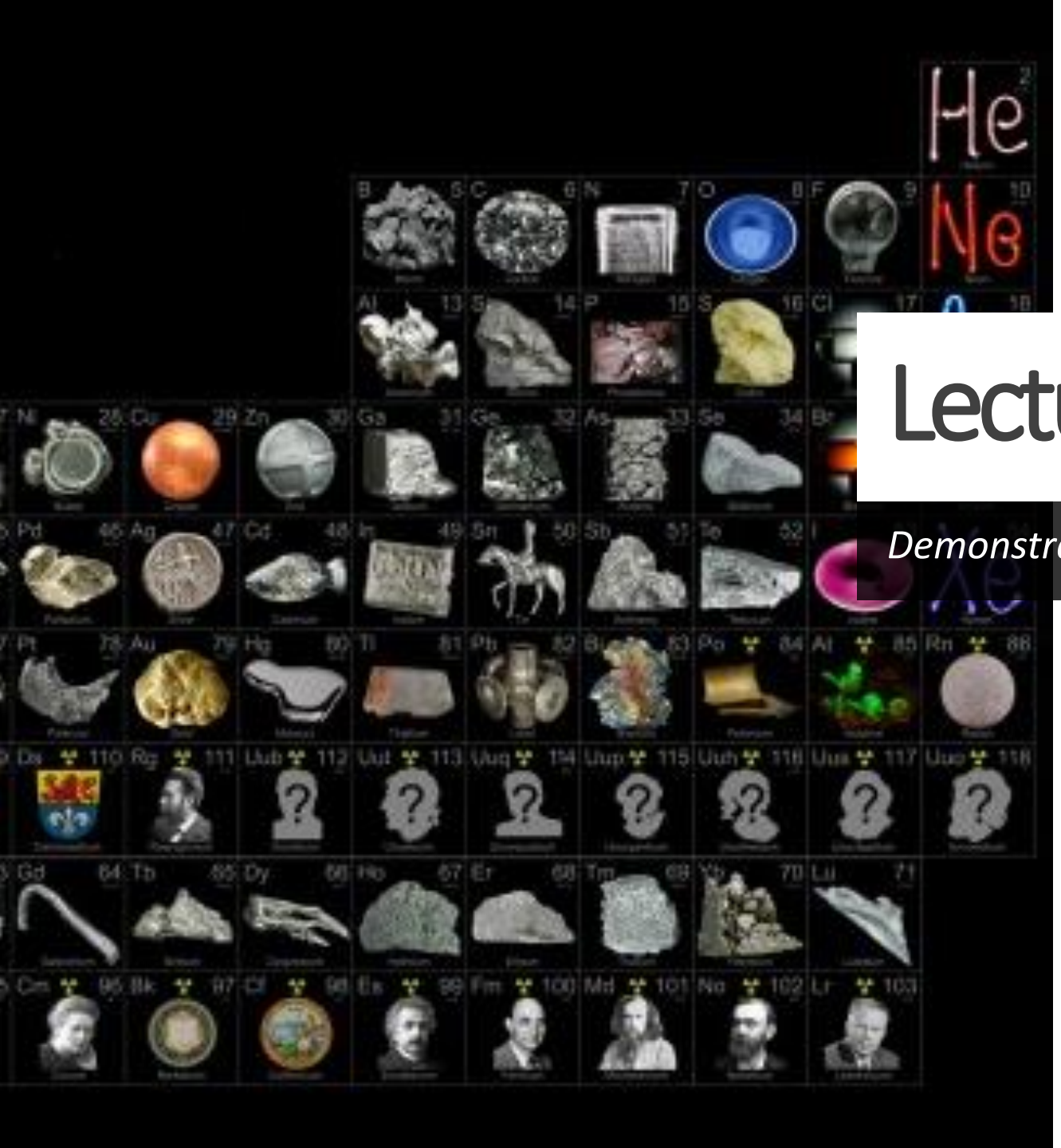


Lecture objectives:

Demonstrate an understanding of:

- How elements are arranged in the periodic table.
- Trends within groups of the periodic table
- Periodicity

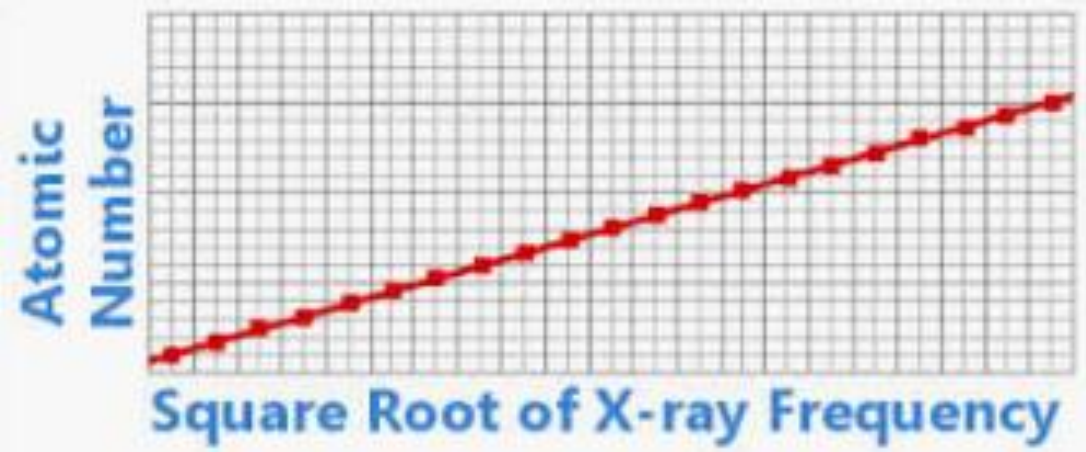
- Ordered elements according to increasing atomic mass.
- Similar properties in vertical columns.
- Left gaps for elements that had not been discovered.

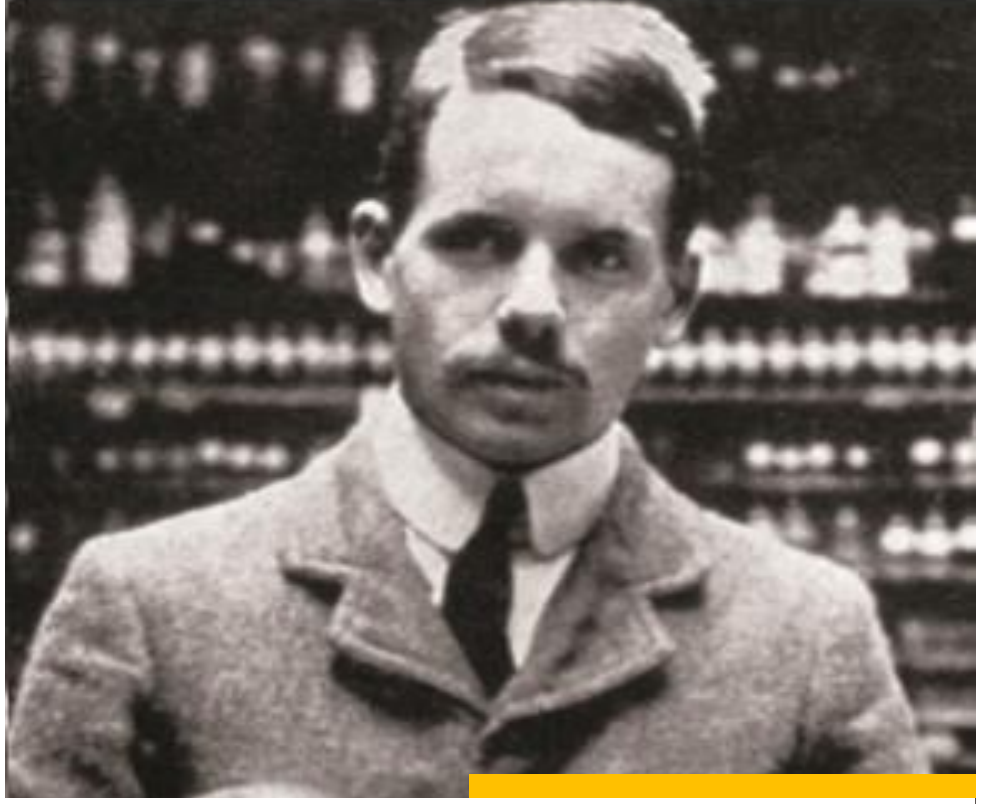
Property	Eka-aluminium (Ea)	Gallium (Ga)
Atomic mass	About 68	70
Density (g/cm^3)	6.0	5.9
Melting point	Low	29.8°c
Formula of oxide	Ea_2O_3	Ga_2O_3
Density of oxide (g/cm^3)	5.5	5.88

The periodic table

How did Mendeleev arrange the elements in the periodic table?

- Today, we know that the **atomic number** gives the **number** of protons.
- He found that certain lines in the X-ray spectrum of each element moved by the same amount each time you increased the **atomic number** by one.





Moseley

The discovery of the atomic number

Comparison:

Mendeleev's & the modern periodic table

Mendeleev	Modern day
• Arranged according to atomic mass • A lot of gaps were present • No group 8/0 predicted	• Arranged by proton number **(what we now call atomic number)** • Gaps filled • Group 8/0 has been discovered

The arrangement of the periodic table

Groups and periods

Groups

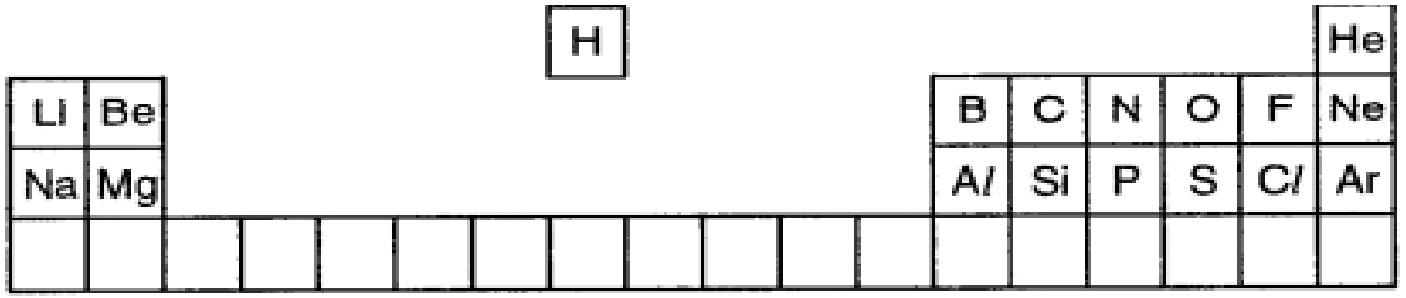
- Vertical columns
- Same number of outer-shell electrons
- Similar chemical properties
- Old system was 1-8. New system in 1-18

Periods

- Horizontal rows
- The number of the highest energy electrons shell in an element's atom

Exam question

This question refers to the elements in the first 3 periods of the periodic table



(a) Identify an element from the first three periods that fits each of the following descriptions.

(i) The element that forms a 2– ion with the same electronic configuration as Ne.

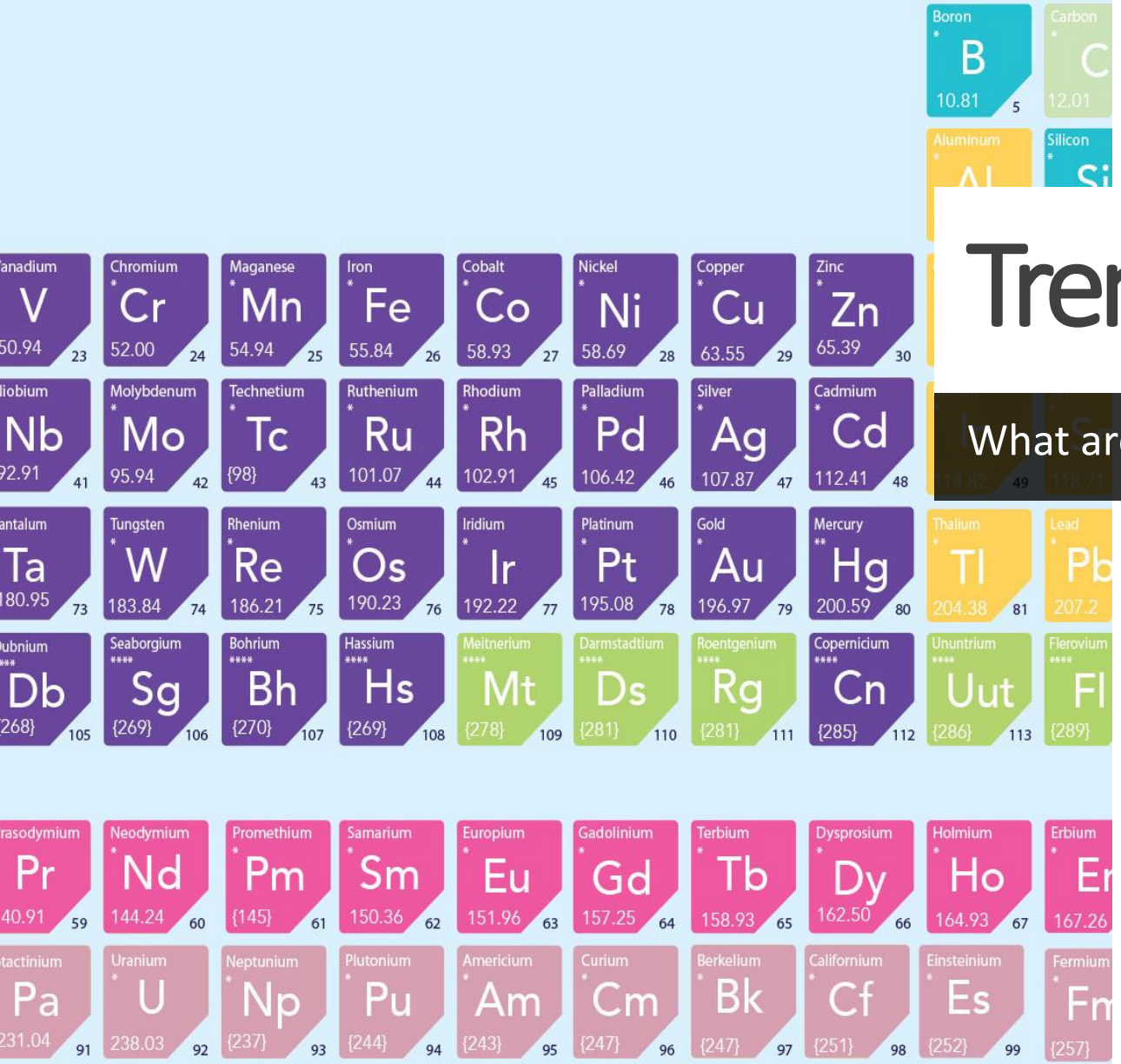
.....

[1]

(ii) The element that forms a 3+ ion with the same electronic configuration as Ne.

.....

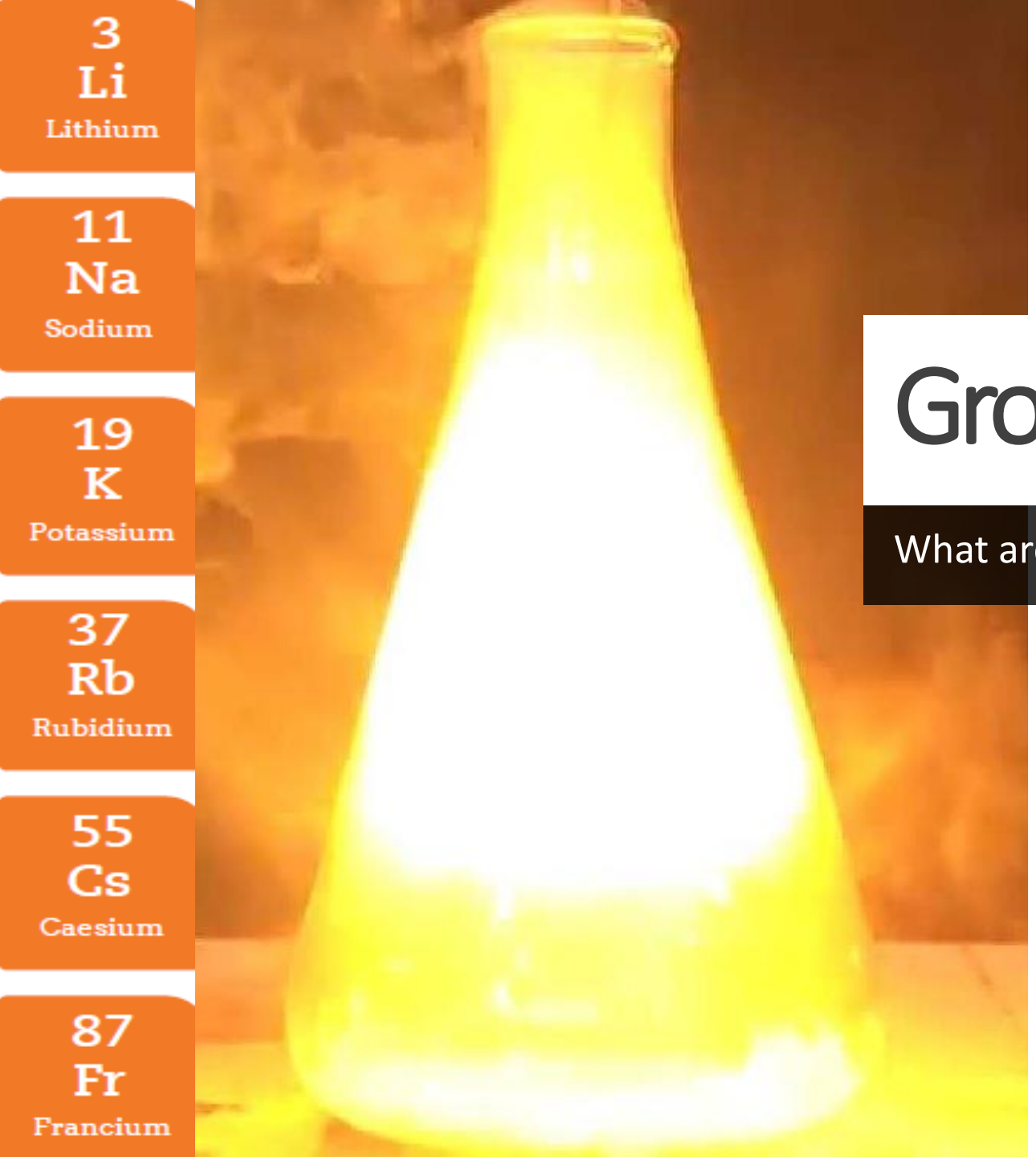
[1]



Trends in groups

What are the trends within a group?

- Melting and boiling points
- Reactivity
- Solubility of compounds



Group 1

What are the chemical and physical trends of group 1?

Group 1 - The Alkali Metals

THE GROUP 1 ELEMENTS ARE SHINY, SOFT, AND HIGHLY REACTIVE METALS, NONE OF WHICH OCCUR NATURALLY AS FREE ELEMENTS

3 Li Lithium

11 Na Sodium

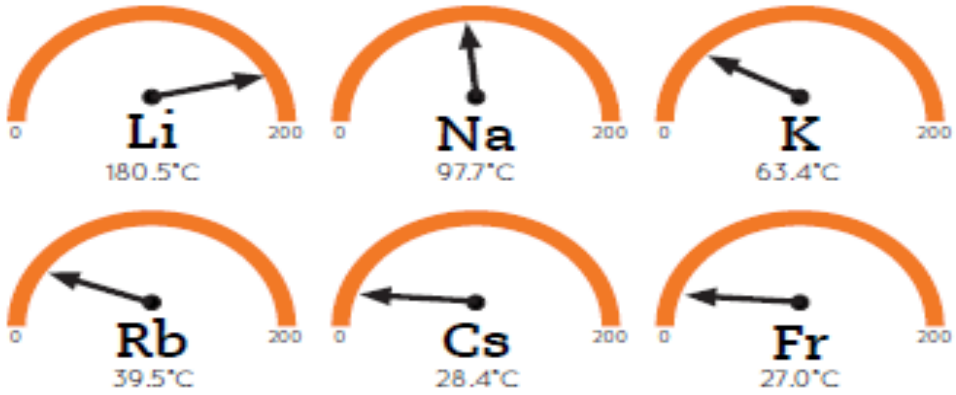
19 K Potassium

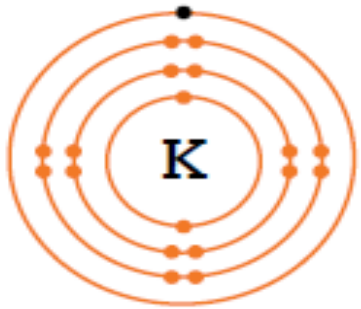
37 Rb Rubidium

55 Cs Caesium

87 Fr Francium

MELTING POINTS





ALL OF THE GROUP 1 METALS HAVE *ONE* VALENCE ELECTRON

THE REACTIVITY OF THE GROUP 1 METALS **INCREASES DOWN THE GROUP** AS THE OUTER ELECTRON GETS *FURTHER FROM THE NUCLEUS* & BECOMES EASIER TO REMOVE

THE ALKALI METALS REACT WITH WATER TO FORM METAL HYDROXIDES

LiOH NaOH KOH RbOH CsOH

ALKALI METALS REACT WITH OXYGEN TO FORM METAL OXIDES

ALKALI METALS REACT WITH HALOGENS TO FORM IONIC SALTS

USES OF THE ALKALI METALS

LITHIUM
ANTI DEPRESSANTS
BATTERIES

SODIUM
STREET LAMPS
TABLE SALT

POTASSIUM
FERTILISERS
SOAPS

RUBIDIUM & CAESIUM
ATOMIC CLOCKS

FRANCIUM
RADIOACTIVE

Group 2

What are the chemical and physical trends of group 2?

Group 2 - The Alkaline Earth Metals

THE GROUP 2 ELEMENTS ARE SHINY, SILVERY-WHITE, AND SOMEWHAT REACTIVE METALS, SOME OF WHICH OCCUR NATURALLY AS FREE ELEMENTS

4 Be Beryllium

12 Mg Magnesium

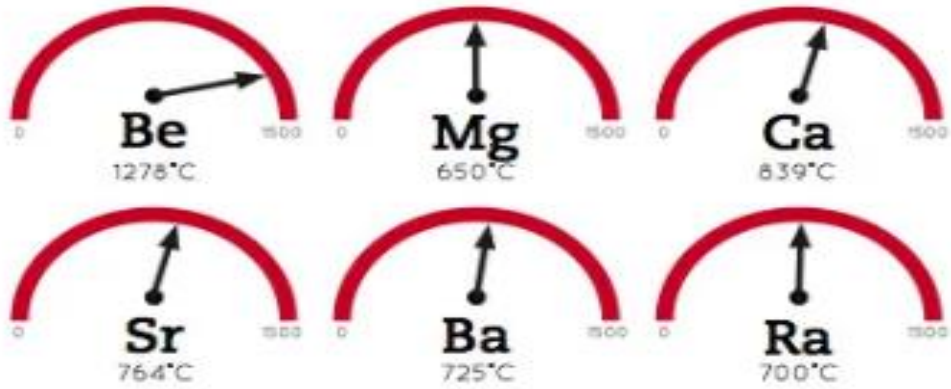
20 Ca Calcium

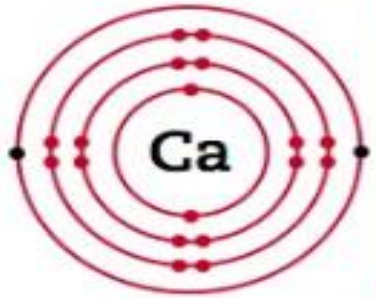
38 Sr Strontium

56 Ba Barium

88 Ra Radium

MELTING POINTS





ALL OF THE GROUP 2 METALS HAVE *TWO* VALENCE ELECTRONS

THE REACTIVITY OF THE GROUP 2 METALS **INCREASES DOWN THE GROUP** AS THE OUTER ELECTRONS GET *FURTHER FROM THE NUCLEUS* & BECOME EASIER TO REMOVE

THEY ARE LESS REACTIVE THAN GROUP 1

THE ALKALINE EARTH METALS REACT WITH WATER TO FORM **METAL HYDROXIDES...**

$$M(OH)_2$$

EXCEPT FOR **Be** WHICH HAS A PROTECTIVE OXIDE LAYER PREVENTING REACTION

GROUP 2 METALS REACT WITH OXYGEN TO FORM **METAL OXIDES**

GROUP 2 METALS REACT WITH HALOGENS TO FORM **METAL HALIDES**

RADIUM

RADIUM IS A **RADIOACTIVE** ELEMENT WHICH USED TO BE USED TO MAKE **GLOW IN THE DARK PAINT**

USES OF THE ALKALINE EARTH METALS

BERYLLIUM
- EMERALDS
- TELESCOPE MIRRORS

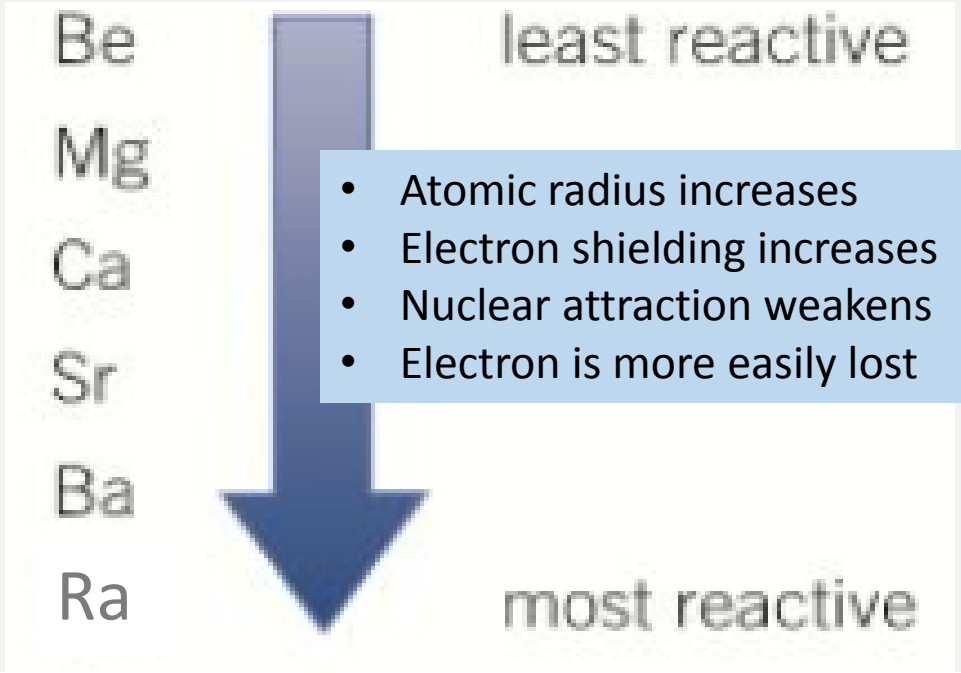
MAGNESIUM
- ALLOY WHEELS
- FLARES

CALCIUM
- BONES
- BLACKBOARD CHALK

STRONTIUM
- FIREWORKS
- TREATING OSTEOPOROSIS

BARIUM
- RAT POISON
- GLASSMAKING

- Redox reactions are the most comment reactions of group 2 elements
- The group 2 metal is oxidised and reduces the non-metal
- This happens with:
  - oxygen
  - water
  - acid

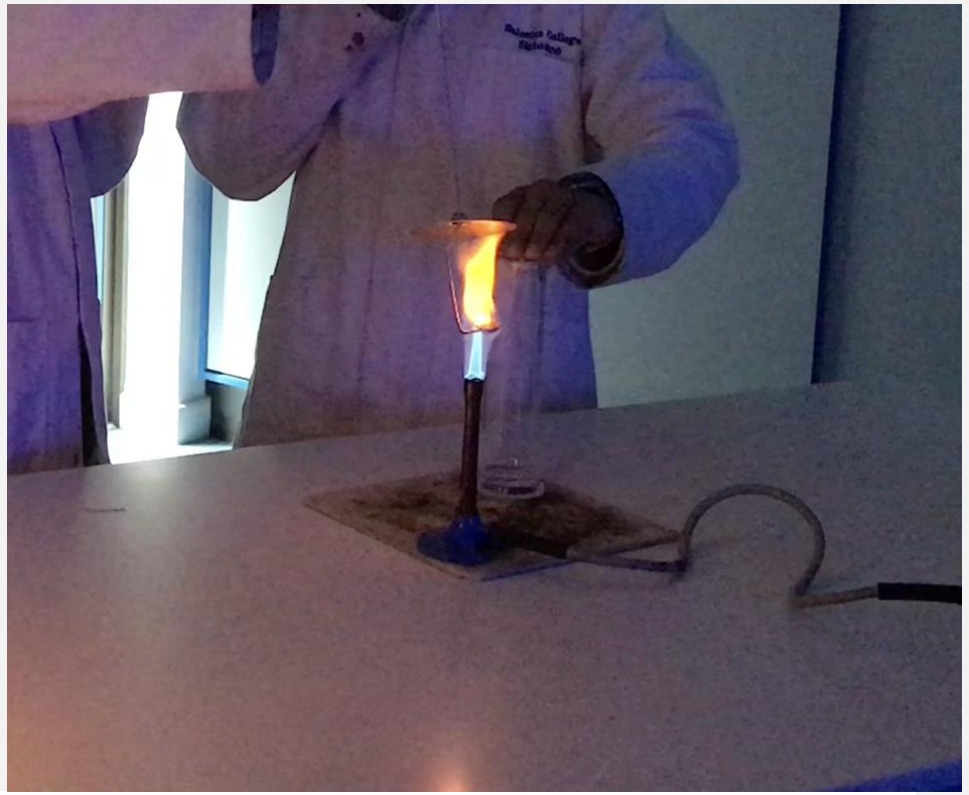


Reactivity

Redox reactions

Redox reaction 1:

Reacting with oxygen



Metal + oxygen → metal oxide

Task:

1. Write the balanced symbol equation for calcium reacting with oxygen
2. Show, using half equations that the calcium is oxidised and the oxygen is reduced.
3. Describe what you would see if a piece of Magnesium was burnt

Redox reaction 2:

Reacting with water

Metal + water → metal hydroxide + hydrogen

Task:

1. Write the balanced symbol equation for magnesium reacting with water
2. Show, using half equations that the magnesium is oxidised and the hydrogen is reduced.
3. Describe what you would see during this reaction

Redox reaction 3:

Reacting with acid

Metal + acid → metal salt + hydrogen

Task:

1. Write the balanced equation for calcium reacting with hydrochloric acid
2. Show, using half equations that the calcium is oxidised and the hydrogen is reduced.
3. Describe what you would see during this reaction
4. How could you prove the gas evolved was hydrogen

Group 2 oxides & hydroxides

React with water

Oxides react with water forming OH^- ions

$CaO_{(s)} + H_2O_{(l)} \rightarrow Ca^{2+}_{(aq)} + 2OH^-_{(aq)}$

Hydroxides are only slightly soluble in water.

Form a solid when added in excess (past the saturation point)

$Ca^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Ca(OH)_2$

Hydroxide	Trend
$Mg(OH)_2$	• solubility increases
$Ca(OH)_2$	• pH increases
$Sr(OH)_2$	• alkalinity increases
$Ba(OH)_2$	

Group 2 hydroxides

What is the trend in solubility and alkalinity?

9
F
Fluorine

17
Cl
Chlorine

35
Br
Bromine

53
I
Iodine

85
At
Astatine

117
Uus
Ununseptium

Group 7

What are the chemical and physical trends of group 7?

Group 7 - The Halogens

GROUP 7 IS THE ONLY GROUP THAT CONTAINS ELEMENTS IN ALL THREE STATES OF MATTER. THEY ARE ALL REACTIVE NON-METALS

9 F Fluorine

17 Cl Chlorine

35 Br Bromine

53 I Iodine

85 At Astatine

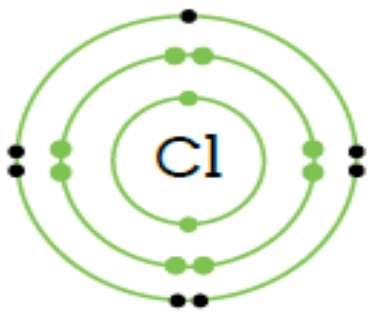
117 Uus Ununseptium

IODINE & ASTATINE
SOLIDS AT ROOM TEMPERATURE

BROMINE
LIQUID AT ROOM TEMPERATURE

FLUORINE & CHLORINE
GASES AT ROOM TEMPERATURE

THE HALOGENS ALL FORM DIATOMIC MOLECULES *EXCEPT* FOR ASTATINE



ALL OF THE GROUP 7 ELEMENTS HAVE *SEVEN* VALENCE ELECTRONS

THE REACTIVITY OF THE HALOGENS **DECREASES DOWN THE GROUP** AS IT BECOMES HARDER TO *ADD AN ELECTRON*

1 GRAM ESTIMATED AMOUNT OF **ASTATINE** IN THE EARTH'S CRUST AT ANY ONE TIME

HYDROFLUORIC ACID LEACHES CALCIUM FROM BONES AND CAN CAUSE VERY PAINFUL BURNS

IT ALSO **DISSOLVES GLASS**

THE HALOGENS REACT WITH OXYGEN TO FORM **HALOGEN OXIDES**

THE HALOGENS REACT WITH METALS TO FORM **METAL HALIDES**

THE HALOGENS ARE USED AS **OXIDISING AGENTS** *WHILST* HALIDE IONS ARE USED AS **REDUCING AGENTS**

F_2 I^- IONS

USES OF THE HALOGENS

FLUORINE
TOOTHPASTE
REFRIGERANT GASES

CHLORINE
BLEACH
CHEMICAL WARFARE

BROMINE
FIRE RETARDANT MATERIALS

IODINE
DISINFECTANTS

Group 7 (17)

Physical properties

- Do not occur in elemental form in nature
- Found as stable halides dissolved in water and in Sodium or potassium solid deposits e.g. salt mines
- All form diatomic gases apart from astatine

Physical properties

What are the trends in the physical properties of group 7 elements?

Halogen molecule	Number of electrons	Boiling point / °C	Appearance and state at RTP	Trend
F_2	18	−188	pale yellow gas	 • more electrons • stronger London forces • more energy required to break the intermolecular forces • boiling point increases
Cl_2	34	−34	pale green gas	
Br_2	70	59	red-brown liquid	
I_2	106	184	shiny grey-black solid	
At_2	170	230	never been seen	

Trends in reactivity

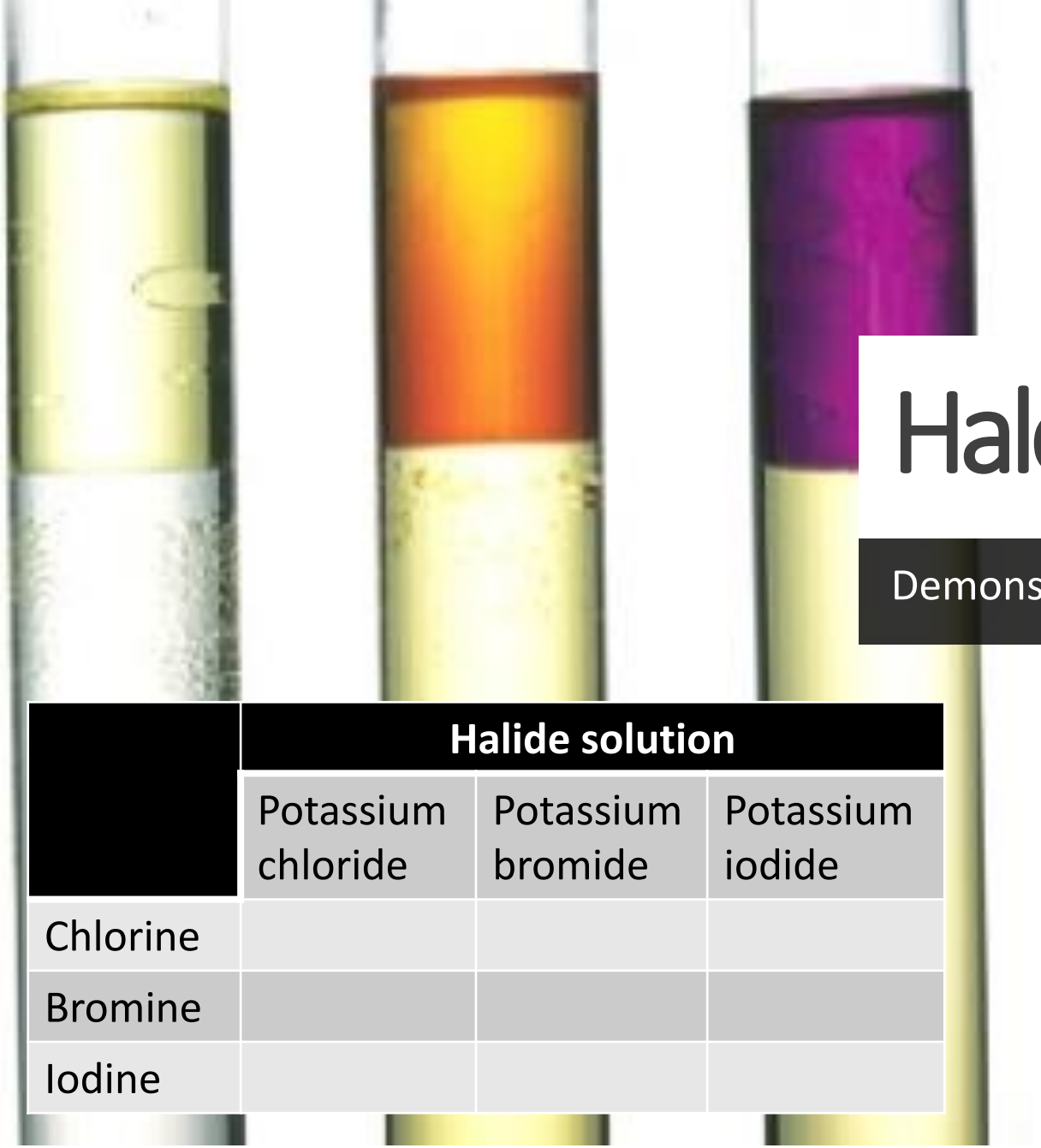
What are the trends in the chemical reactivity of group 7 elements?

Halogen molecule	Atomic radius	Number of inner shells	Trend
F_2		1	• Atomic radius increases • More inner shells so shielding increases • Less nuclear attraction to capture an electron from another species • Reactivity decreases
Cl_2		2	
Br_2		3	
I_2		4	
At_2		5	

Reactions of group 7

Redox reactions

- They are **oxidising reagents** (so are **reduced** in the process)



Halogen displacement

Demonstrating the reactivity of the halogens

	Halide solution		
	Potassium chloride	Potassium bromide	Potassium iodide
Chlorine			
Bromine			
Iodine			

- A more reactive halogen displaces a less reactive halogen in a compound.
- Redox reaction

The results

Cl_2	Br_2	I_2
solution in water		
pale green	orange	brown

solution in cyclohexane (top layer)		
pale green	orange	violet

This question is about halogens.

Bromine is used to extract iodine from a solution containing iodide ions.

i. Write an ionic equation for the reaction.

[1]

ii. Explain why iodine is less reactive than bromine.

Exam question

Halogen displacement

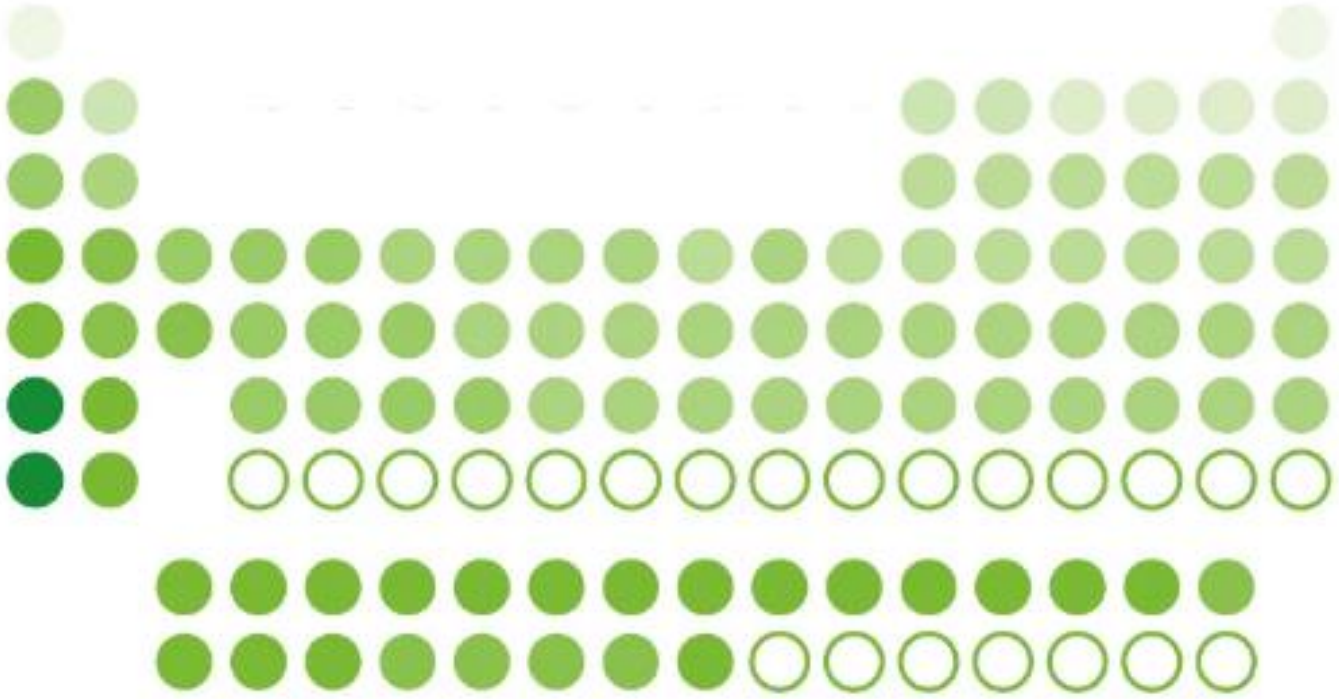
Periodicity

What are the trends across a period?

Periodicity

What is periodicity?

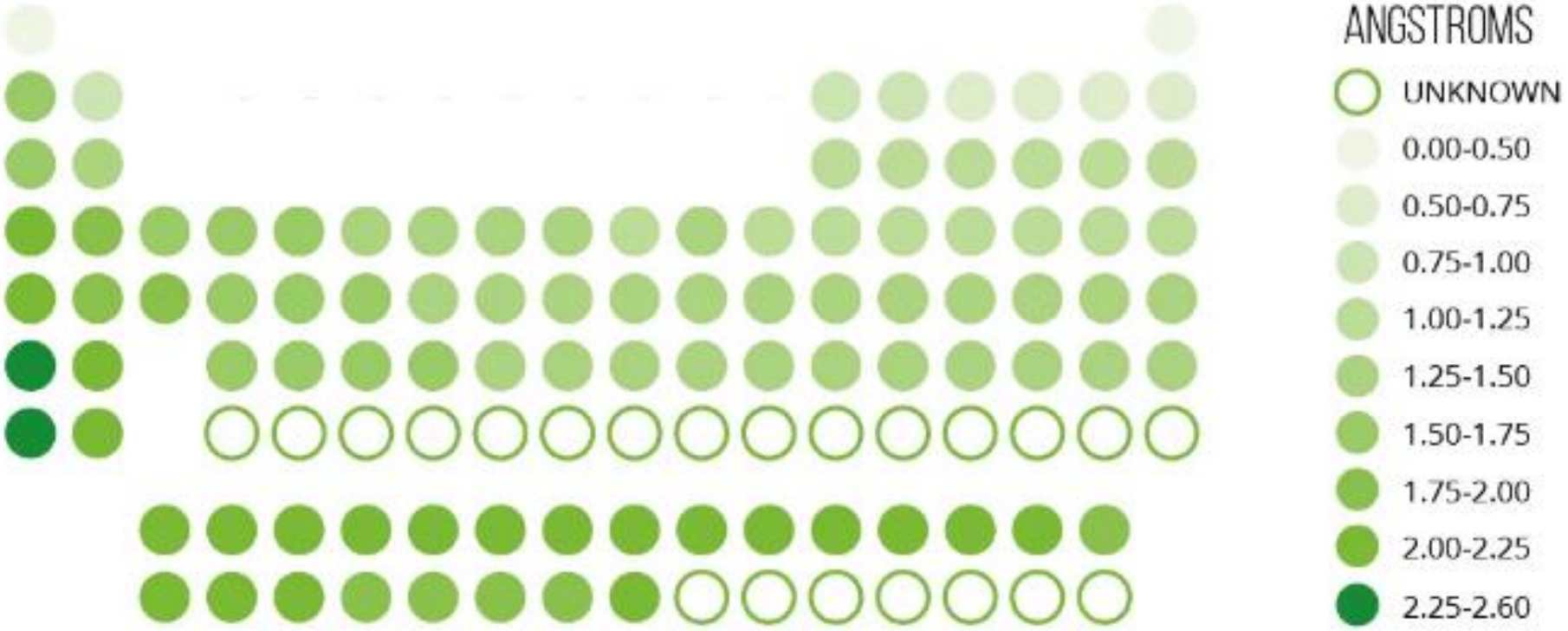
- A repeating trend in properties of the elements across each period of the periodic table
  - Electron configuration
  - Ionisation energy
  - Structure
  - Melting points



Atomic radii

- Nuclear charge increases
- Electron shielding remains approximately constant
- So electrons are drawn into the nucleus

Decreases across a period



Atomic radii

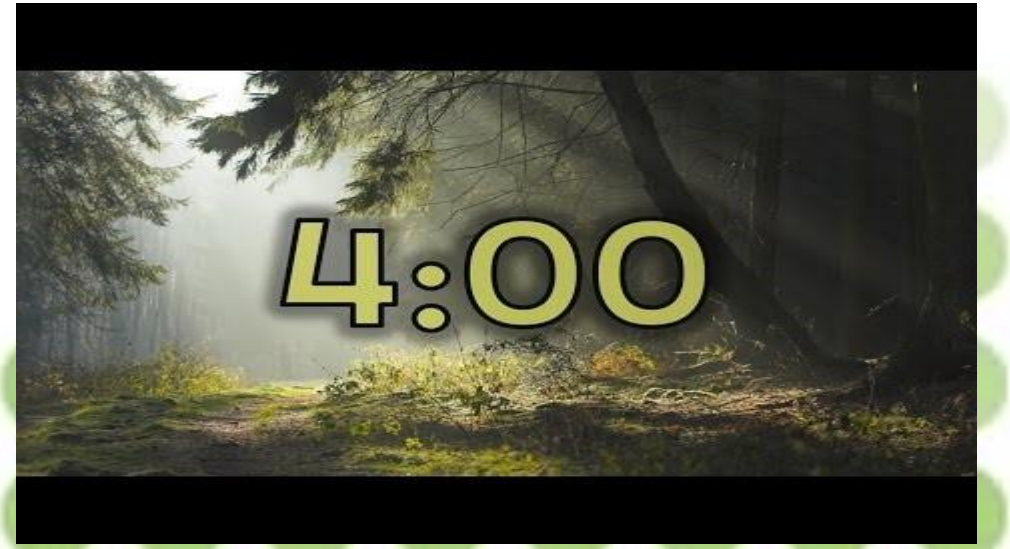
- Nuclear charge increases
- Electron shielding increases due to an addition of a new shell
- So nuclear attraction is less

Increases down a group

The Periodic Table is arranged in periods and groups.

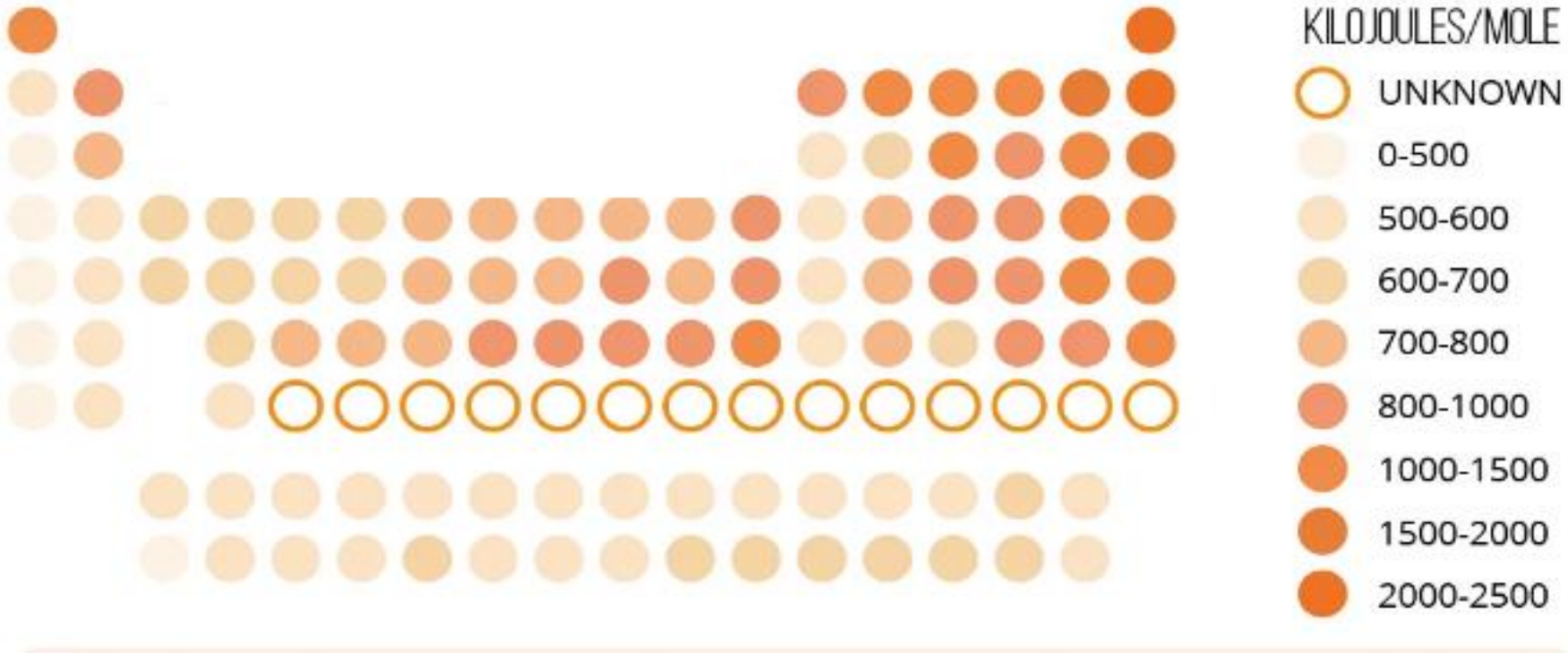
Elements in the Periodic Table show a periodic trend in atomic radius.

State and explain the trend in atomic radius from Li to F.



Exam question

6 marks



Ionisation energies

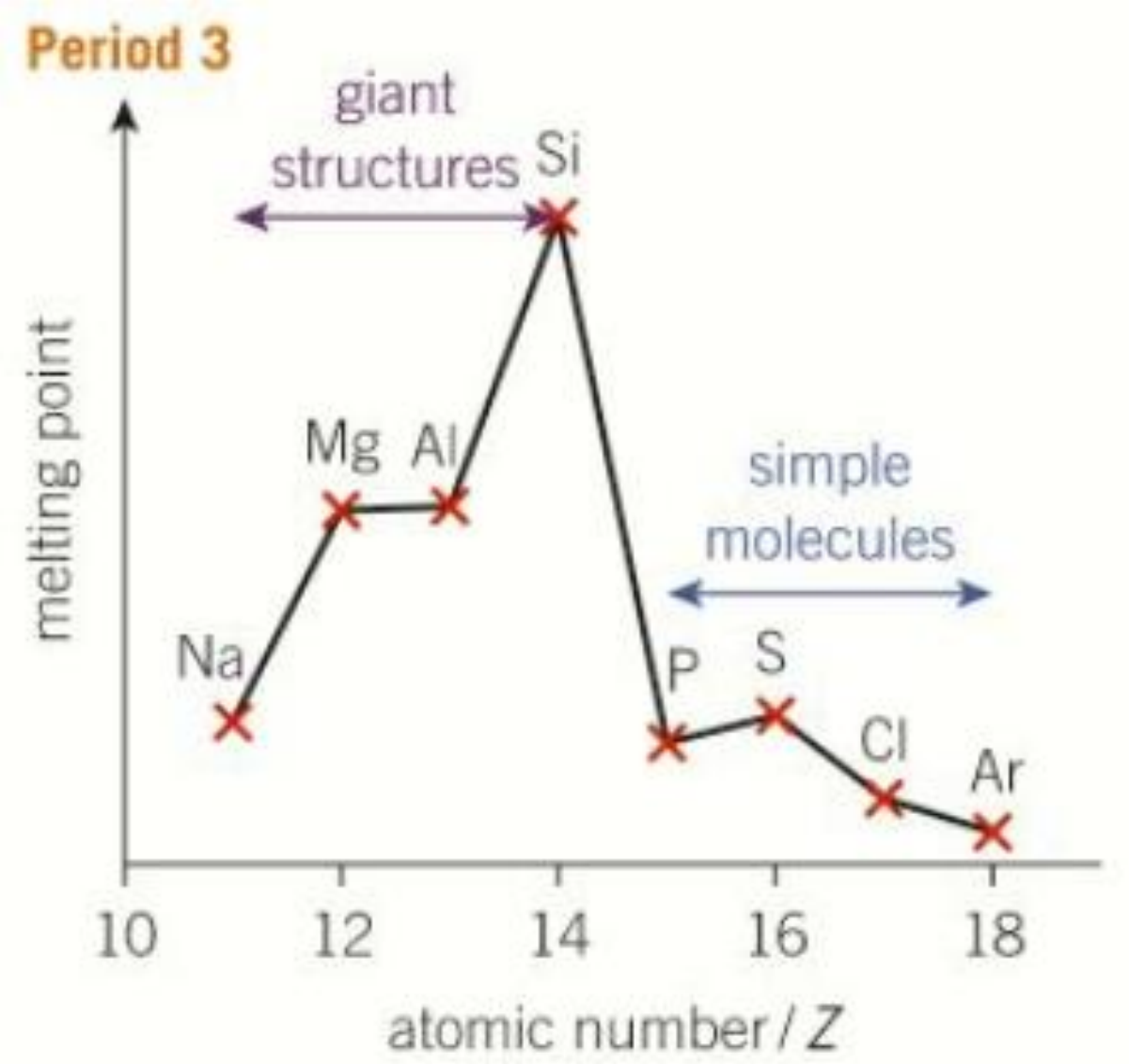
Increases across a period

- Nuclear attraction imcreases
- Electron shielding remains relatively constant
- So atomic radius decreases
- The electron is harder to remove

Structures

How does the structure of an element change across a period?

Giant metallic structure Strong metallic bonds between cations and delocalised electrons		Giant covalent structure Strong covalent bonds between atoms		Simple molecular structure Weak London forces between molecules			
Li	Be	B	C	N_2	O_2	F_2	Ne
Na	Mg	Al	Si	P_4	S_8	Cl_2	Ar



Melting & boiling points

Linked to the structure

- Giant structures= high boiling point and melting point
- Simple molecular substances= low melting and boiling points

Exam question

A chemist determines some properties of two substances, **C** and **D**.

The results are shown in the table.

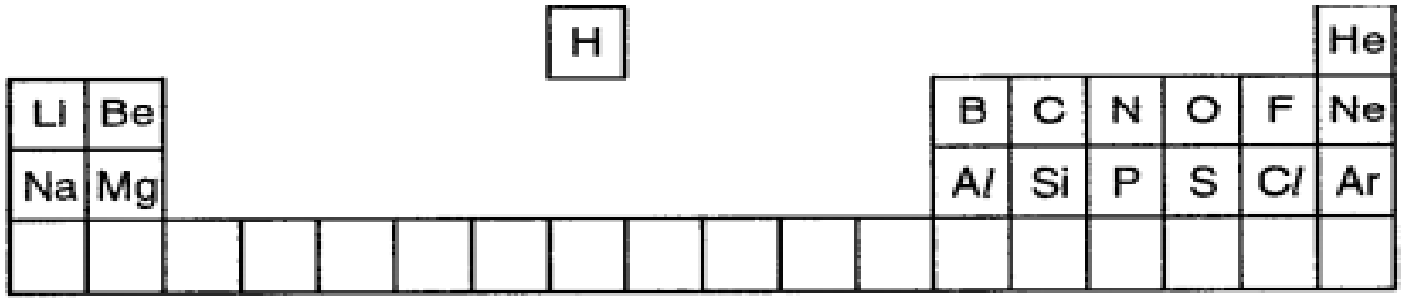
	C	**D**
Melting point / °C	660	801
Electrical conductivity when solid	Yes	No
Electrical conductivity when molten	Yes	Yes
Solubility in water	No	Yes

Which row correctly identifies the bonding and structure in **C** and **D**?

	C	**D**
A	giant ionic	giant metallic
B	giant ionic	giant ionic
C	giant metallic	giant metallic
D	giant metallic	giant ionic

Exam question

This question refers to the elements in the first 3 periods of the periodic table



(vii) The element with the largest atomic radius.

..... [1]

(viii) The element in Period 3 with the highest boiling point.

..... [1]