• Avogadro’s hypothesis - equal volumes of gases measured at the same volume and pressure contain the same number of molecules.
• Gas molar volume - 22.414dm³ @ s.t.p. (273K, 1atm) & 24.414dm³ @ r.t.p. (293K, 1 atm)
• Boyle’s Law* - At a constant temperature, the volume of a fixed mass of gas is inversely proportional to pressure \( P = \frac{1}{V} \)
  \[ P_1V_1 = P_2V_2 \]
• Charles’ Law - The volume of a fixed mass of a gas at constant pressure is directly proportional to its temperature in Kelvin \( V = \frac{T}{T_1} \)
  \[ V_1/T_1 = V_2/T_2 \]
• A gas which obeys both Boyle’s and Charles’ Law is said to behave ideally.
• Ideal gas equation: \( P_1V_1/T_1 = P_2V_2/T_2 \)
  \[ PV = nRT \] (P in Pa; V in m³; T in K; R = 8.314 J mol / K)
• \( P = \frac{p \times RT}{RMM} \)

Finding RMM of volatile liquid using a gas syringe

1. Gas syringe containing a little air is placed into steam jacket - with heat air expands and volume is noted when a steady reading is obtained.
2. Liquid is weighed accurately in syringe & injected into the gas syringe (empty syringe weighed).
3. As the liquid vaporises the gas syringe barrel is pushed out and the total volume of air vapour is measured when the reading is steady.
4. Temp and atmospheric pressure in the steam jacket are noted.

Real Gases

• Ideal gas equation not obeyed at high pressure and low temperature.
• Assumes that mols move randomly, occupy negligible volume, exert no pressure on each other & have elastic collisions (assume that no energy is lost).
• CsCl - Body Centred Cubic Structure
  • 8:8 coordination
  • Other examples - CsBr, CsCN

• ZnS
  • Anion at the centre of a tetrahedron of cations and vice-versa
  • 4:4 coordination

• CaF$_2$ - 1:2 structure
  • Similar to CsCl with half of the positive ions missing since F$^-$ is very electronegative.
  • Each F$^-$ has 4 Ca$^{2+}$ ions tetrahedrally arranged around it.
  • 8:4 coordination

• If cationic radius inc - coordination no inc —> can accommodate more ions around it

Properties of Ionic compounds

• High melting/boiling point
  • Electrostatic forces between oppositely charged ions are very strong.
  • Large amount of energy must be supplied to make ions vibrate & eventually break.
  • Also have a high latent heat of vaporisation.

• Brittle
  • Crystals are hard but can be cleaved - split using a very sharp razor edge.
  • Occurs due to a slight shift - similarly charged ions come in contact with each other.
  • Repulsion results which fractures the crystal.
  • In a metal - metallic bond is a cluster of anions surrounded by a delocalised cloud which fills gaps between anions. When you apply force, metal will change shape as electron cloud moves quickly to surround moved anions : no repulsion occurs & won’t break —> malleable.
  • If you bend constantly - will heat up due to constant movie of the e- cloud. Inc in KE - can overcome forces of attraction & break.

• Conduction of Electricity
  • Only when molten or in solution
  • When solid - ions held together in crystal - unable to move : no electricity can be conducted.
  • When molten/in solution ions are free to move and an electrical current can pass through.

• Solubility in water
  • When dissolves in water the ionic crystal breaks down, forming separate Na$^+$ and Cl$^-$ in solution.
  • Water has an uneven e- distribution - polar molecule. There is a greater e- conc. near the O atom rather than the H atom.
  • Positive ions are attracted from the negative end of a water mol, and anions are attracted from the positive end.
  • The new ion-solvent bonds formed results in a release of energy which helps break down the strong electrostatic forces in the crystal lattice.
  • Process is called Solvation/Hydration.
  • Do not dissolve in organic solvents since these have weak molecular forces between them which are not strong enough to penetrate the crystal lattice.
  • Why is there a diff in solubility in some compounds? - diff in ionic radius
Graph of Group 4,5,6,7 hydrides

- Group 4 - inc in b.p.t.'s.: inc in mol size down group.: inc in Van der Waals.
- Group 5 - trend like Group 4 except NH\textsubscript{3} - mostly H-bonds.: higher b.p.t.
- Group 6 - same concept with H\textsubscript{2}O - extremely higher b.p.t. since 2 H-bonds.
- Group 7 - inc. Van der Waals HF - H-bonding. B.p.t. should be higher than Group 6. F: F has 3 lone pairs, but can only form 1 H-bond because of stearic hindrance.

- F —> dense e- cloud (small molecule) — difficult for another e- molecule to approach another— strong repulsion. Doesn’t form more than 1 H-bond due to stearic hindrance — packing problems — geometry of electronegativity — atom doesn’t allow formation of 2nd H-bond.

Dimerisation of Carboxylic acids

- Dimer - forms H-bonds with itself.
- Occurs when ethanoic acid is dissolved in benzene.
- Benzene —> non-polar solvent, so ethnic acid would rather bond with itself than interact with benzene.
- Dimers do not form in water - water is very polar so forces of attraction between ethanoic acid & water is stronger than forces attraction between itself (to form dimer) .: weak acid.
- Inc non-polar chain length —> sol. in water dec. accordingly.
- Solubility of longer chained acids decreases rapidly with size. The hydrophobic tails het between H\textsubscript{2}O mols and breaks H-bonds. The H-bonds are replaced with weaker Van der Waals.

Giant Covalent Structures

- Allotropes of Carbon - Polymorphic - exist in more than one crystalline form.
- Diamond
  - Each C forms 4 bonds (sp\textsuperscript{3} hybridised) forming tetrahedral arrangement.
  - Strong arrangement where all atoms are bounded by strong covalent bonds.
  - Virtually non-reactive.
  - No free electrons.
• **Enthalpy of Neutralisation** $\Delta H^0_{\text{neutralisation}}$
  • The heat absorbed when an acid and a base react to form 1 mole of water under standard conditions.

• **Bond Dissociation Enthalpy** of $\Delta H^0_{\text{BDE}}$
  • Enthalpy change when 1 mole of bonds are broken in the gaseous state.
  • $X-Y_{(g)} \rightarrow X_{(g)} + Y_{(g)}$

### Experiment to find the Enthalpy of Neutralisation

- **Calorimeter** - used to measure heat evolved when 1 mole of strong acid reacts with 1 mole of a strong base.

1. Determine heat capacity of calorimeter by pouring a known mass of substance at known temperature with known SHC. The temp is noted. The Heat Capacity ($C$) is the energy required to raise the temp by 1K.

2. A neutralisation reaction is carried out in the cal. Note the rise in temp. when known amounts of standard acids and alkalis are reacted in the calorimeter.
  - In all thermochemical measurements, it is the usual practice to consult a cooling curve to compensate for any heat losses, even though the cal used is highly insulated.
  - The cooling curve is obtained by taking a number of measurements before the actual experiment begins and the temp also recorded a no of times after the expt is started.

3. The cooling curve is then extrapolated backwards to the time of reaction and the corrected temp rise read from graph.

### Experiment to find enthalpy of combustion

- Spirit burner contains fuel: weight after - weight before = mass of fuel burnt
- Metal cal. contains known mass of water.
- Thermometer to measure change in temp
- Draught shield to reduce heat losses.
- Burn as much fuel as possible to reduce error.