3.1 - The periodic table

3.1.1 - Periodicity
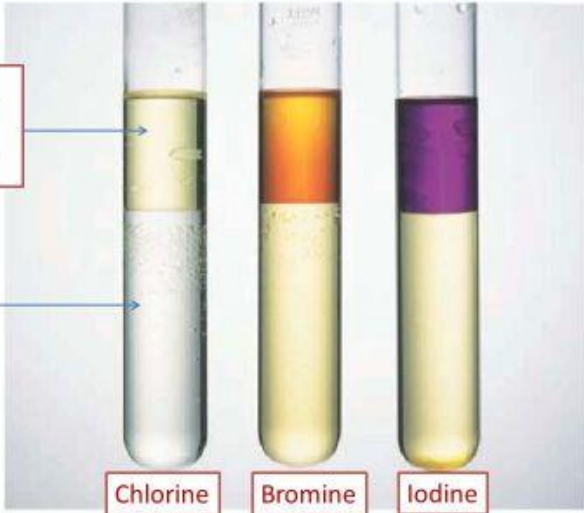
What is periodicity?	A repeating pattern across different periods.
Why do P$_4$ and S$_8$ have high boiling and melting points?	They have more electrons ∴ more London forces which require more energy to overcome.
Define first ionisation energy	Energy required to remove an electron from each atom (1) in one mole of gaseous atoms (1).
Why are there sharp and slight increases in successive ionisation energies?	 • Slight increases ∵ removing an electron ⇒ smaller atomic radius (∵ less repulsion between subshells) ⇒ stronger attraction. • Sharp increase ∵ less shielding and smaller atomic radius ⇒ stronger attraction.
Why do electronegativites and ionisation energies decrease down groups?	• Increased atomic radius and more shells ⇒ more shielding ⇒ less attraction ⇒ easier to remove. • Increased shielding outweighs the increase in proton no. and thus nuclear charge.

Why does electronegativity and ionisation energy increase across periods?	● Greater nuclear charge $\Rightarrow$ reduced atomic radius $\Rightarrow$ greater attraction $\Rightarrow$ harder to remove ● During this, shielding stay the same.
Why is boron ($1s^22s^22p^1$)'s first ionisation energy less than beryllium ($1s^22s^2$)'s?	p-orbital e^- has a higher energy than the s-orbital e^- $\therefore$ easier to remove. *It's all about a new factor now having an effect relative to the previous element.*
Why is oxygen ($1s^22s^22p^4$)'s first ionisation energy less than nitrogen ($1s^22s^22p^3$)'s?	Electrons now pair in the same orbital $\Rightarrow$ repel one another $\Rightarrow$ easier to remove.
What is a metallic bond?	Strong electrostatic force of attraction (1) between cations and delocalised electrons (1).
What 3 things are metallic bonds affected by?	● No. of protons (the more, the stronger). ● No. of delocalised electrons per atom (the more, the stronger). ● No. of shells (the more, the weaker $\therefore$ electron shielding).
Why are metals malleable?	Layers of cations can easily slide over each other.
What shape do group 4 elements form?	Tetrahedral.
Give 3 examples of giant covalent molecules	● Diamond. ● Graphite. ● Silicon dioxide (SiO_2).
Give 2 reasons for why graphite is soft	● Layers can easily slide of each other. ● Weak London forces.

3.1.2 - Group 2

Why does the reactivity increase down group 2?	First ionisation energy decreases $\Rightarrow$ less energy required to remove the outermost electron.
Why does reactivity decrease down group 7?	- Increased atomic radius and increased shielding due to more shells $\Rightarrow$ less attraction between the nucleus $\Rightarrow$ gains electrons less readily. - The increase in proton number and thus **nuclear charge** is outweighed by an increase in shielding.
How are group 2 compounds used in farming?	- To neutralise acidic soils. - E.g., CaO, $Ca(OH)_2$, or $CaCO_3$.
Give a group 2 compound used in medicine, how it's used, and why it's used	$Mg(OH)_2$ (milk of magnesia) is used to neutralise excess stomach acid $\because$ not too strong an alkaline - E.g., $Mg(OH)_2(aq) + 2HCl \rightarrow Mg_2Cl_2(aq) + H_2O(l)$
Give 3 observations of a group 2 element in acid	1. Fizzing (more vigorous, further down). 2. Metal (ribbon) dissolving (faster, further down). 3. Solution heating (more, further down).
What changes for group 2 hydroxides down the group and why?	$Mg(OH)_2$ Solubility increases $Ca(OH)_2$ $Sr(OH)_2$ Alkalinity increases $Ba(OH)_2$ Solubility increases and alkalinity increases $\because$ more HO^- ions are released $\therefore$ higher pH.
What is decomposition (with an example equation)?	- The separation of a single compound into two or more elements/compounds. $2ClO_2 \rightarrow Cl_2 + 2O_2$.
What changes for group 2 carbonates down the group?	Ease of thermal decomposition decreases.

3.1.3 - Group 7

What is a halide?	A binary compound of a halogen.
Give the colours and states of the first 4 halogens at room temperature	

Name	Colour	State
F_2	Pale yellow	Gas
Cl_2	Green	Gas
Br_2	Red-brown (like bromine water)	Liquid
I_2	Grey	Solid

You Guys Read Gore.
YELLOW GREEN RED GREY (down the group).

Why must experiments with halogens be done in a well-ventilated area?	They're powerful oxidising agents ∴ toxic.

How will Br_2 and I_2 appear when in cyclohexane compared to water?

- Br_2 is orange in both.
- I_2 is orange/brown in water and violet in cyclohexane.

Non-polar/hydrocarbon solvent example cyclohexane layer

Water layer

Chlorine   Bromine   Iodine

fig. 2.5.13 Halogens are more soluble in organic solvents such as cyclohexane than in water.

Br_2 being orange can be remembered by bromine water being orange.

What is displacement of group 7 elements (with an example)?	● More reactive halogen displacing less reactive halide from its aqueous solution. ● E.g., $F_2(g) + 2NaCl(aq) \rightarrow 2NaF(aq) + Cl_2(g)$
What is disproportionation and what can it happen with?	● A reaction where same element is both oxidised and reduced. ● Any halogen (except fluorine $\because$ very powerful oxidising agent).
Why will chlorine and water bleach universal indicator?	The ClO⁻ ion from the HClO $_{(aq)}$ produced is a powerful oxidising agent.
Give 1 pro and 1 con of adding Cl₂ to water	+ It kills bacteria (1) - It could form chlorinated hydrocarbons which are toxic/carcinogenic (1)
How does chlorine react with water?	$$Cl_2(g) + H_2O(l) \rightarrow HCl(aq) + HOCl(aq)$$ This is a disproportion reaction.
How is bleach formed, why this way, and what is used as the bleach?	● By reacting chlorine with **cold dilute sodium hydroxide solution** as it has a higher solubility. ● $Cl_2(aq) + 2NaOH(aq) \rightarrow NaClO(aq) + NaCl(aq) + H_2O(l)$ ● The mixture of NaClO is used as bleach. The NaClO is just called sodium chlorate (I).

3.1.4 - Qualitative analysis

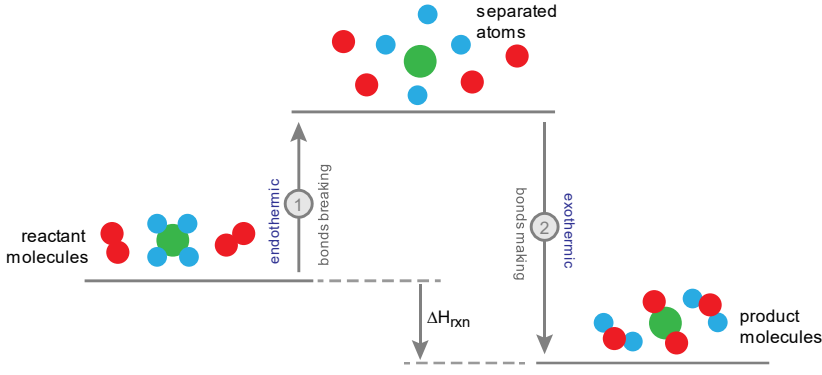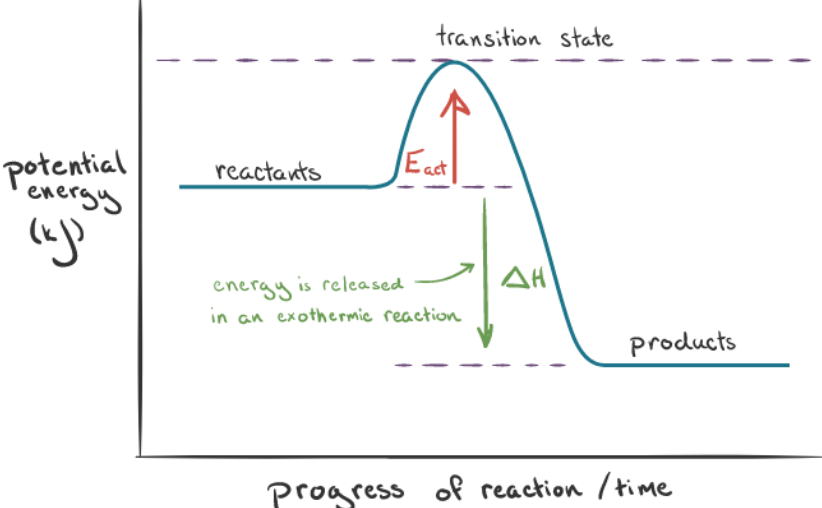|	
What is the test for carbonates?	1. Add nitric acid. If you see effervescence, it **COULD** contain a carbonate $\because$ a gas is produced. 2. Bubble this gas through limewater. If cloudy then gas was CO_2 and thus carbonate was present.
Give the test for sulfate ions	1. Add nitric acid to dissolve any carbonates to prevent the formation of $BaCO_3$ precipitate (aka a false positive which can mask desired observations). 2. Add barium nitrate solution (or anything with Ba^{2+}). 3. If white ppt forms, you have a sulfate present. *This is because $Ba^{2+}_{(aq)} + SO_4^{2-}_{(aq)} \rightarrow BaSO_{4\,(s)}$*

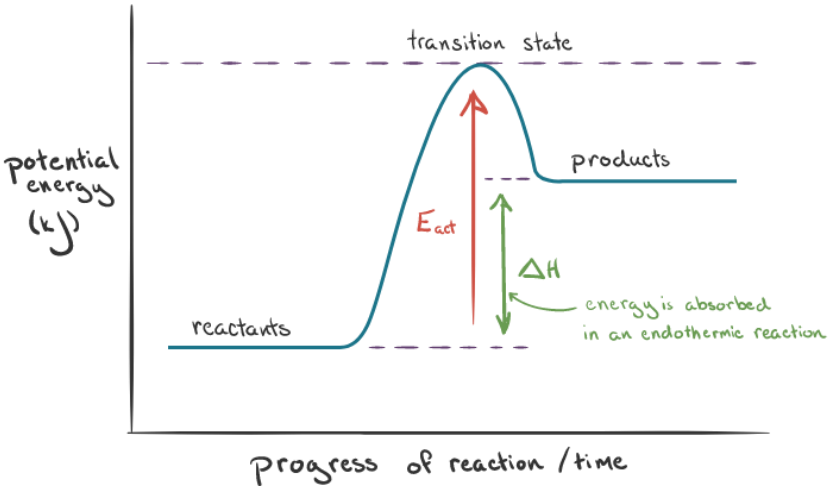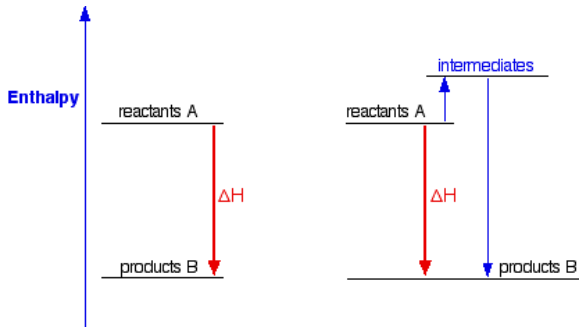|	
Give the test for halides with a precaution and example equation	1. Add nitric acid to dissolve any carbonates to prevent the formation of Ag_2CO_3 precipitate (aka a false positive which can mask desired observations). 2. Add silver nitrate solution. 3. If the precipitate formed is **white** it's silver **chloride**, if it's **cream** then it's silver **bromide**, and if it's **yellow** then it is silver **iodide**. $$Ag^+(aq) + Br^-\,(aq)\ \rightarrow AgBr\,(s)$$ *To remember it, learn the halides in alphabetical order **BCI** then the colours in alphabetical order **CWY**.*
How can you be certain of the result of the halide test?	1. Add ammonia solution. 2. Silver **chloride** dissolves under dilute solution. Silver **bromide** dissolves under concentrated solution. Silver **iodide** will not dissolve at all.

What is the test for ammonium ions?	● Add sodium hydroxide solution and **HEAT GENTLY**.
	
	$$NaOH(aq) + NH_4Cl(aq) \rightarrow NH_3(g) + NaCl(aq) + H_2O(l)$$
	
	● If NH_3 is produced then you can…
	  ○ Smell for it.
	  ○ Use damp litmus paper and hover it over the tube. This will turn blue under NH_3 as NH_4OH will form on the paper.

Why should you not use certain acids when performing qualitative analysis?	● As the acid releases the ions you're testing into the solution so you will **OBVIOUSLY** get a positive test for follow-up tests. ● Only use these if you plan to perform **ONE TEST / NO FOLLOW-UP TESTS.** *If you use HCl or H_2SO_4 then you will obviously get a positive test for SO_4 and Cl_2.*
What is a precipitation reaction (with example)?	When cations and anions in aqueous solution combine to form an insoluble ionic solid. E.g., $$Ag^+ + Cl^- \rightarrow AgCl$$ $$Ni^{2+} + 2HO^- \rightarrow Ni(OH)_2$$

In what order should you carry out anion tests? Why?	• Carbonate - Sulfate - Halide (Ca-S-H). • Continue if it is negative. • Adding Ba^{2+} to CO_3^{2-} produces a white ppt of BaCO3. • Adding Ag^+ to CO_3^{2-} produces a yellow-grey ppt of Ag2CO3. • Adding Ag^+ to SO_4^{2-} produces a white ppt of Ag2SO4.

3.2 - Physical chemistry

3.2.1 - Enthalpy changes

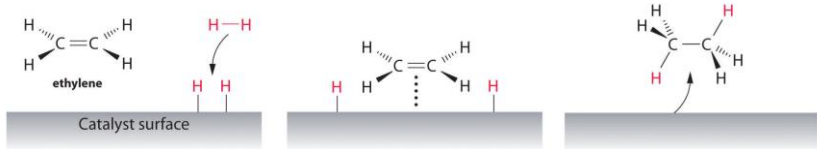| Why can 'enthalpy change of formation' not be measured directly?	Many different compounds can form from the same constituent elements.
How is enthalpy change calculated?	$$\Delta H = \frac{\pm q}{n}$$ The plus or minus depends on whether the reaction was exothermic or endothermic.
Breaking bonds is … because …	• Endothermic. • Energy is put into the system. *Atoms become less stable as they have no bonds and lots of energy.*
Making bonds is … because …	• Exothermic. • Energy is released to the surroundings. *Despite the little energy needed to make a bond, the molecule becomes more stable when bonded and thus releases energy.*
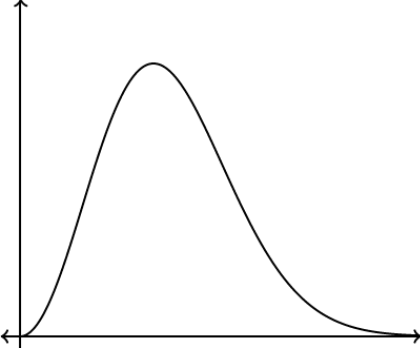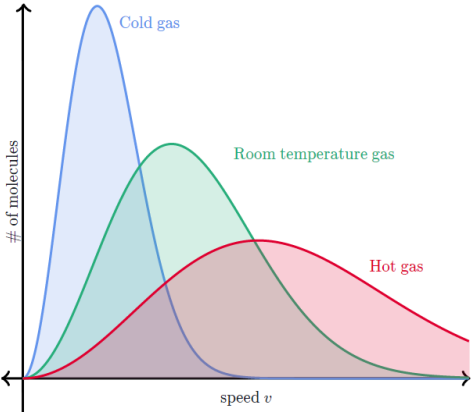
What is ΔH°r equal to? (using bond enthalpies)	 ΔH°$_r$ = ΣΔH $_{(bonds\ broken)}$ - ΣΔH $_{(bonds\ formed)}$
What is activation energy defined as?	The minimum energy required of particles to collide to start a reaction.
Draw and label the energy profile diagram for an exothermic reaction	 ΔH is negative as energy is **EX**iting the system to surroundings and thus **EX**othermic. Taking up to be the positive direction, we have the arrow pointing downwards.

Draw and label the energy profile diagram for an endothermic reaction	 transition state potential energy (kJ) E_{act} products ΔH energy is absorbed in an endothermic reaction reactants Progress of reaction / time ΔH is positive as energy is **EN**tering the system from the surroundings and thus **EN**dothermic. Taking up to be the positive direction, we have the arrow pointing downwards.
What does Hess' Law state?	The enthalpy change of reaction is independent of the route taken. Enthalpy reactants A ΔH products B intermediates reactants A ΔH products B
What 2 things are required of particles to react?	● Minimum kinetic energy (i.e., activation energy). ● Correct orientation.
How does concentration affect the rate of reaction?	Increasing concentration ⇒ more particles per unit volume (1) ⇒ more frequent successful collisions (1) ⇒ increased rate of reaction (1). *If the question explicitly says double concentration, say double particles and thus double frequency of successful collisions.*
How does temperature affect the rate of reaction?	Increasing temperature ⇒ higher % of particles with K_E greater than E_A (1) ⇒ more frequent successful collisions (1) ⇒ increased rate of reaction (1).
How does surface area affect the rate of reaction?	Increasing surface area ⇒ more sites are exposed (1) ⇒ more frequent successful collisions (1) ⇒ increased rate of reaction (1).

What are the limitations of calorimetry?	• Heat loss to surroundings. • Non-standard conditions. • Heat capacity of container not included. • Contents of calorimeter may evaporate.

3.2.2 - Reaction rates

Give 2 ways of improving an experiment that uses a gas syringe	1. Let the reaction carry on until the gas syringe has stopped moving. 2. Wait for the gas to cool to room temperature before reading.
What do catalysts do?	Provide an alternate reaction pathway with a lower activation energy without being used up.
Give 2 reasons for why catalysts are useful	1. Allow reactions to occur at lower temperatures and pressure ∴ less (thermal) energy demand. 2. Allow for reactions with better atom economies ∴ less waste.
What is a homogeneous catalyst and its benefits and drawbacks?	● A catalyst in the same phase/state as the reactants. + It means more molecules can react. - It makes separating molecules at the end harder.
What is a heterogeneous catalyst and its benefits and drawbacks?	● A catalyst in a different phase/state to the reactants. + Can be easily separated. • Reactions only take place on the catalyst's surface.
Describe what occurs on the surface of the nickel catalyst in the hydrogenation of ethene	1. The reactants (H_2 and C_2H_4) are **ADSORBED** onto the catalyst surface. 2. The bonds weaken (1) and they react to form C_2H_6. 3. The product (C_2H_6) is **DESORBED** from the surface. Thus… $$C_2H_4 + H_2 \rightarrow C_2H_6.$$
What is the key idea behind the 'Boltzmann Distribution'?	Particles gain or lose energy in collisions with others and thus travel at different speeds.

Give the key features of the 'Boltzmann Distribution'	● It starts at the origin because no particles have no energy. ● The peak (E_{mp}) is the most probable energy (which is different from the mean). ● It never meets the x-axis as there is no maximum energy for particles. *The area under the graph represents the number of molecules.*
What does the 'Boltzmann Distribution' look like at different temperatures and why?	Increasing the temperature shifts the distribution towards more particles having higher energies (more than any E_A) **AND** wider range of energies due to more frequent collisions. *The area under the graph represents the number of molecules.* The x-axis is also energy / kinetic energy of the molecules.

3.2.3 - Chemical equilibrium

What is a closed system?	A container in which nothing cannot enter or leave except for heat.
What is dynamic equilibrium?	● When the forward and backward reactions are occurring at the same rates.

	● Thus, the concentrations stay constant. Yet, the amounts of each may differ.
What is Le Chatelier's Principle?	If a dynamic equilibrium is changed, the position of the equilibrium to oppose this change.
What happens to the equilibrium position if the temperature is increased and why?	● Favours the endothermic side. ● To minimise the effect of temperature rise by absorbing heat.
What happens to the equilibrium position if pressure is increased?	● Favous the side producing the least moles of gas (1). ● To minimise the effect of pressure increase by reducing the number of particles. *Remember that each mole takes 24dm^3 under standard conditions!*
What compromises must be made when altering the equilibrium position and why?	**Pressure:** ● A lower pressure when favouring the side with less moles ∵ high pressures are difficult to produce (high electrical costs in pumping gas) and difficult to contain (to withstand high pressures). ● A higher pressure when favouring side with more moles otherwise the rate of reaction will be too low. **Temperature:** ● A higher temperature when favouring the exothermic side otherwise the rate of reaction will be too low. ● A lower temperature when favouring the endothermic side ∵ expensive to use too much fuel. ● Because this allows for a reasonable rate of reaction / costs without shifting the equilibrium too far to the left/right. ● You will have a smaller equilibrium yield but more product produced in unit time.
What happens to the equilibrium position if a catalyst is added and why?	● No change as it increases the rate of reaction for both sides. ● The time at which equilibrium is achieved is reduced.
What is the equation for the equilibrium constant (K_c)?	$aA + bB \rightleftharpoons cC + dD$

| | $$K_c = \frac{[C]^c \, [D]^d}{[A]^a \, [B]^b}$$ |