Bonding, Structure and Energy AS 91164

Lewis Structure (A usually – 2/3 correct to get grade)

Year	Molecules	Question type
2014	none	angle
2015	O_2 OCl_2 CH_2O	Lewis only
2016	H_2O CS_2 PH_3	+ angle
2017	$HOCl$ $COCl_2$ NF_3	+ angle + shape name
2018	H_2S NH_3 BF_3	+ angle + shape name
2019	CH_4 NCl_3 OF_2	+ shape name

- ❑ Usually need 2/3 correct for Achieved.
- ❑ Don't spend more than a few minutes
- ❑ Leave a difficult diagram
- ❑ Use information in the table to answer the E shape question
- ❑ Come back and fill in table if you have time (after

Shapes (E1 – Must do question)

Discuss each molecule separately using the same steps

Year	Molecules
2014	From parts of a molecule
2015	CCl_4 $COCl_2$
2016	H_2O CS_2 PH_3
2017	$HOCl$ $COCl_2$
2018	NH_3 BF_3
2019	CH_4 NCl_3 OF_2

- ❑ Start with number of regions around central atom (2 or 3 or 4)
- ❑ Name central atom!
- ❑ add the VSEPR theory (REPLUSION)
- ❑ link arrangement shape to number of regions – and bond angle!!
- ❑ name bonding and non-bonding pairs
- ❑ name final shape (will be same if no non-bonding pairs)_

Polarity (E2 – Must do question)

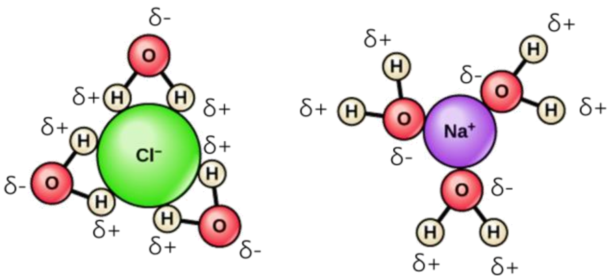
Year	Molecules
2013	Molecule MX_2
2014	SO_2 and CO_2
2015	BeCl BF_3
2016	NH_3 BH_3
2017	CH_2Cl_2 CCl
2018	HCN CO_2
2019	$CHCl_3$ NH_3

- ❑ Start with the individual bonds in the molecule, name them!
- ❑ MUST talk about **electronegativity difference** and link to even or uneven sharing of electrons to form (or not) dipoles
- ❑ Move onto whole molecule – symmetrical or not – link to shape!
- ❑ Symmetrical shapes – linear, trigonal planar, tetrahedral
- ❑ Non-symmetrical shapes – bent, trigonal pyramid
- ❑ Finally state the polarity

State polarity of molecule first
State polarity of bonds (name atoms)
Link symmetry to shape to dipoles cancelling out (or vice versa)

Solubility (E3 – Must do question)

Year	Molecules
2014	NaCl
2016	$ZnCl_2$ – in solids Questions
2017	NaCl
2018	Any ionic solids as example
2019	I_2 in H_2O and cyclohexane



- ❑ Not every year
- ❑ Will usually require a diagram if **ionic solid**
- ❑ Discuss strong water-water bonds (won't break unless polar/ionic solid)
- ❑ Discuss ion-water bonds forming
- ❑ Use polar/non-polar term ONLY if molecular solid

Only a few ions of each are needed in the diagram. Don't forget to label

Solids (E4 - Usually 2 x E)

MUST remember particles and bonding for each solid

Substance (for example)	Type of substance	Type of particle	Attractive forces between particles
$C_{(s)}$ Graphite	Covalent (extended) network (2-D)	Atom	Strong Covalent
$Cl_{2\ (s)}$ chlorine	Molecular	Molecules	Weak intermolecular forces
$CuCl_{2(s)}$ copper chloride	Ionic	Ion	Ionic bonds / electrostatic attraction
$Cu_{(s)}$ copper	Metal	Atom / cations and electrons	Metallic bonds / electrostatic attraction

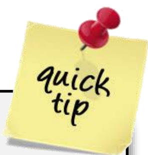
There will not necessarily be one example for each group but information from this chart MUST be used in following questions about solids

- ❑ Use the terms in the chart above in your long answer.
- ❑ You must discuss structure AND then link to property

Year	Substances in chart	Conductivity	Solubility	Ductility/malleability/Brittle	State/ MP
2013	Cu/C(graphite)/CuCl/Cl_2	Cu/C(graphite)		Cu/C(graphite)	Cl_2 CuCl
2014	Mg / I_2	Q1. C (Graphene) Q2. Mg / I_2	Mg / I_2	Mg / I_2	C (graphene)
2015	Cu / PCl_3 / SiO_2 / KCl	PCl_3	Cu/SiO_2/KCl Pick any 2	Cu/SiO_2/KCl Pick any 2	PCl_3
2016	$ZnCl_2$ /C(graphite)/CO_2	$ZnCl_2$/ C(graphite)	$ZnCl_2$/ CO_2		
2017	Al/$MgCl_2$/S_8			Al/$MgCl_2$/S_8	Al/$MgCl_2$/S_8
2018	A/B/C/D given properties	ionic – identified from chart			Molecular/metallic From chart
2019	Na/NaI/I_2	C(Graphite) /CO_2		Na/NaI	

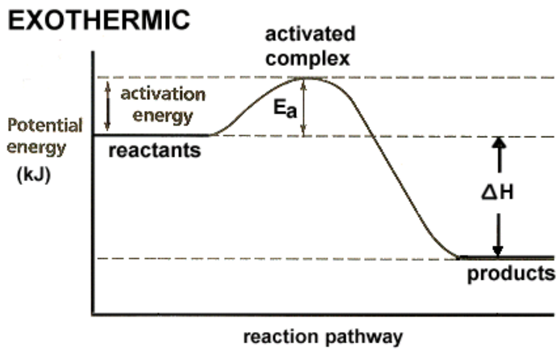
Substances KEY words for structure			
Molecular	Ionic	Metallic	Covalent Network
X is a molecular substance composed of X molecules together by weak intermolecular forces.	X is an ionic substance. It is composed of a lattice of positive X ions and X chloride ions held together by strong electrostatic attraction between these positive and negative ions. This bonding is directional.	X is a metallic substance composed of X atoms packed together. Valence electrons are loosely held and are attracted to the nuclei of the neighbouring X atoms, which results in metallic bonding, that is non-directional.	Graphite is a covalent network solid composed of 2-D layers of C atoms covalently bonded to three other C atoms. The remaining valence electrons are delocalised (ie free to move) between layers Diamond / SiO_2 is a covalent network made up of atoms covalently bonded together in a 3D lattice structure.

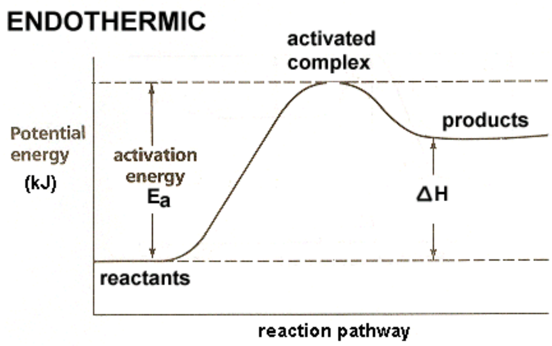
Enthalpy (E5 – Usually M + E in recent years)



- ❑ ALWAYS answer endo OR exo questions – 50% chance of A usually
- ❑ Breaking Bonds (solid→liquid→gas) is ENDOTHERMIC
- ❑ Forming Bonds (gas→liqid→solid) is EXOTHERMIC
- ❑ Endothermic – ABSORBS energy
- ❑ Exothermic – RELEASES energy

Year	Endo or EXO	Grade	Longer answer	Grade
2013	Ammonium nitrate +kJ Glucose combustion	M		
2014	NaOH temp increase Water to ice	A		
2015	Hand warmers heat Glucose photosynthesis	A	Labelled energy diagram (exo) + breaking and making bonds	E
2016	Cod packs Copper sulfate -kJ	A	Labelled energy diagram (exo) + link evapouration to endo	
2017	$CaCl_2$ temp increase	M	Labelled energy diagram (exo) + link evapouration to endo	E
2018	Ammonium chloride dissolving respiration	A	Evapouration link to endo Link diagram to exo	M x 2
2019			Melting ice	E



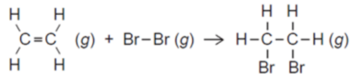
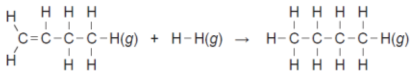


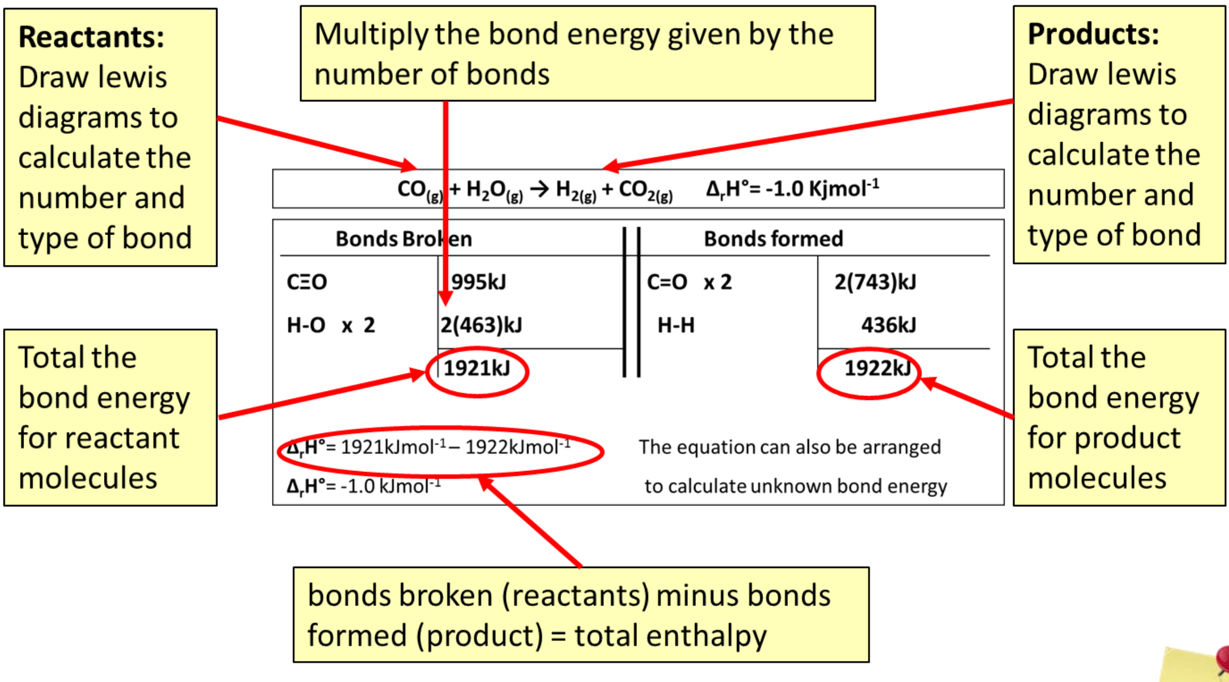
Thermochemical Calculations (E6)

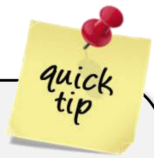
Year	A	B	C	Grade
2013	yes	yes	Yes – 2 equations	E x 2
2014			Yes – 2 equations	E
2015			Yes – 2 separate equations Reasons experimental data different from actual	E x 3
2016			Yes- 2 equations	E
2017			Yes- 2 equations	E
2018	yes		Yes – 1 equation	E x 2
2019	yes		Yes – 2 separate equations	E x 2

Question Type	Given Thermochem equ.	Asked for	Calculate By: Don't forget units!
A	+ actual enthalpy released/absorbed	Number of moles for given enthalpy amount	1. enthalpy per ONE mol substance = enthalpy (kJ) from equation / substance co-efficient in eq. 2. n = kJ given / kJ per 1 mol.
B	+ mass + molar mass + actual enthalpy released/absorbed	Enthalpy change per 1 mol	1. n=mass/molar mass 2. enthalpy per ONE mol substance = enthalpy (kJ) from equation / substance co-efficient in eq. 3. ΔH = enthalpy given / enthalpy per one mol
C	2 equations +mass of both + molar mass of both	Heat energy of both Comparison sentence	1. n =m/M (for each) 2. enthalpy per ONE mol substance = enthalpy (kJ) from equation / substance co-efficient in eq. (for both) 3. enthalpy = n x enthalpy per ONE mol substance (for both) 4. comparison sentence

Bond Enthalpy calculations (E7)

Year	equation	calculate	Grade
2013	$CH_{4(g)} + Cl_{2(g)} \rightarrow CH_3Cl_{(g)} + HCl_{(g)}$	$\Delta r\ H°$	E
2014	$H_{2(g)} + ½\ O_{2(g)} \rightarrow H_2O_{(g)}\ \Delta_r\ H° = –242$ kJ mol$^{–1}$	bond enthalpy of the O – H bond in H_2O	E
2015		$\Delta r\ H°$	E
2016		$\Delta_r H°$	E
2017	Reaction 1: $N_2H_{4(g)} + O_{2(g)} \rightarrow N_{2(g)} + 2H_2O_{(g)}$ Reaction 2: $N_2H_{4(g)} + 2F_{2(g)} \rightarrow N_{2(g)} + 4HF_{(g)}$	$\Delta_r H°$ Of both	E
2018	$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}\quad \Delta_r H° = –92.0$ kJ mol$^{–1}$	bond enthalpy of the N–H bond	E
2019	$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 4H_2O_{(g)} + 3CO_{2(g)}\quad \Delta_r H = –2056$ kJ mol$^{–1}$	bond enthalpy of the C = O bond	E





- ❑ If calculating bond enthalpy for ONE bond – label as x,
- ❑ calculate $\Delta_r H°$= ∑ (energy of bonds broken) - ∑(energy of bonds formed) and add x to correct side
- ❑ rearrange to isolate x
- ❑ Don't forget that x is a single bond! – divide if more than 1 bond present
- ❑ Enthalpy should be -ve if energy released and +ve if energy absorbed
- ❑ Make sure you add units - kJ mol$^{–1}$
- ❑ Double check correct number of bonds i.e. H_2O has 2 x O-H bonds
- ❑ Do calculations twice – simple errors can be made here

Good luck - you have this!