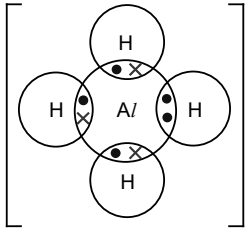
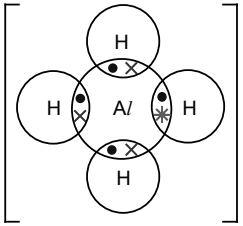
Mark Scheme

Question	Answer	Marks	Guidance
1	D	1	

Mark Scheme

Question			Answer	Marks	Guidance
2	(a)	(i)	 ✓	1	**IGNORE** no brackets, no charge or wrong charge Circles **not** needed **ALLOW** different sign for 'extra' electron, e.g.  **DO NOT ALLOW** 4 dots and 4 crosses
	(b)		NH_4^+: tetrahedral **AND** 109.5(º) ✓ NH_2^-: non-linear **AND** 104.5(º) ✓	2	**ALLOW** 109−110(º) **ALLOW** 104−105(º) **ALLOW** bent, v-shaped, angular **IGNORE** planar, 'not straight'

Mark Scheme

Question			Answer	Marks	Guidance
	(c)	*(i)*	NH_3 has hydrogen bonding **OR** PH_3 does **not** have hydrogen bonding ✓ Hydrogen bonding is stronger **OR** More energy to overcome hydrogen bonding ✓	**2**	**ORA** throughout **Assume that comparison is with PH_3** **DO NOT ALLOW** response that implies covalent or ionic bonds breaking
		(ii)	AsH_3 / As has more **electrons** (than PH_3 / P) ✓ in AsH_3, **stronger/more** induced dipole–dipole interactions **OR stronger/more** London forces (than PH_3) **OR more** energy required to overcome induced dipole–dipole interactions ✓	**2**	**ORA** throughout **ALLOW** larger **electron** cloud **ALLOW** 'forces' **OR** 'bonds' for 'interactions' **ALLOW** instantaneous/temporary–induced dipole interactions **ALLOW** dispersion forces **IGNORE** van der Waals' / vdW **IGNORE** permanent dipole–dipole **DO NOT ALLOW** response that implies covalent or ionic bonds breaking
			Total	**7**	

Mark Scheme

Question	Key	Marks	Guidance
3	C	1	**ALLOW** 3 (This is the trigonal planar atom)

Mark Scheme

Question			Answer	Marks		Guidance
4	(a)		Throughout • **ALLOW** bonding regions for bonded pairs • **ALLOW** diagrams for communicating **two** bonds, **two** lone pairs and hydrogen bonding in ice • **IGNORE** responses about open lattice/tetrahedral structure in ice			
			Ice Ice has hydrogen bonds/bonding ✓ **$H_2O(g)$** 2 bonded pairs **AND** 2 lone pairs ✓ **Repulsion** Lone pairs repel more (than bonded pairs) ✓	**3**		**ALLOW** more hydrogen bonding/H bonds For $H_2O(g)$, • **ALLOW** water • **IGNORE** hydrogen bonding
	(b)		It increases/causes/contributes to global warming **OR** C–H bonds vibrate **OR** absorb IR ✓	**1**		**ALLOW** it is a greenhouse gas/increases temp **IGNORE** ozone, radicals **OR** acid rain
	(c)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **IF** answer = $CH_4 \cdot 5.74\,H_2O$ **OR** 5.74 award 2 marks --- **Mole ratio** $n(CH_4) : n(H_2O) = \frac{13.4}{16.0} : \frac{86.6}{18.0}$ **OR** 0.8375 : 4.811 ✓ **Formula** $CH_4 \cdot 5.74\,H_2O$ **OR** 5.74 ✓	**2**		Working to at least 3 SF but **IGNORE** 'trailing zeroes', e.g. **ALLOW** 16 for 16.0 --- **ALLOW** algebraic approach, e.g. $n(CH_4) = n(CH_4 \cdot xH_2O)$ $\frac{13.4}{16.0} = \frac{100}{16.0 + 18x}$ x = 5.74 **ALLOW ECF** from incorrect mole ratio --- For 1 mark, **ALLOW** x with < 2 DP: • x = 5.7 • x = 6 • x = 5.73 from 0.8375 and 4.8 from 0.84 and 4.811 • x = 5.71 from 0.84 and 4.8
	(d)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE**	**4**		

Mark Scheme

Question	Answer	Marks		Guidance
	IF answer = 188 (dm^3) **AND** use of ideal gas equation Award **4 marks** for calculation --- ***n(CH₄) in 1 kg*** $n(CH_4) = \frac{1 \times 10^3}{16.0} \times \frac{13.4}{100}$ = 8.375 **OR** 8.38 (mol) ✓ ***Rearranging ideal gas equation*** $V = \frac{nRT}{p}$ ✓ ***Substitution of values into $V = \frac{nRT}{p}$:*** • *Calculated value of n(CH_4) (Use **ECF**)* • *R = 8.314 **OR** 8.31* • *T in K: 273 K* • *p in Pa **OR** kPa 101 **OR** 101 × 10^3 **OR** 1.01 × 10^5* *e.g.* $\frac{8.375 \times 8.314 \times 273}{(101 \times 10^3)}$ **OR** $\frac{8.375 \times 8.314 \times 273}{101}$ ✓ *Final volume in dm^3 to **3 SF*** V = 188 (dm^3) ✓			**ALLOW** use of *M*(answer to **(c) OR** 119.32 *Examples* From $n(CH_4 \bullet 5.74\,H_2O)$ $\frac{1 \times 10^3}{119.32}$ = 8.38(1) → 188 (dm^3) From $n(CH_4 \bullet 5.7\,H_2O)$ $\frac{1 \times 10^3}{118.6}$ = 8.43(2) → 189 (dm^3) From $n(CH_4 \bullet 6\,H_2O)$ $\frac{1 \times 10^3}{124.0}$ = 8.06 (mol) → 181 (dm^3) --- **IF** $V = \frac{nRT}{p}$ is omitted, **ALLOW** when values are substituted into rearranged ideal gas equation.
	COMMON ERRORS **Use of 298 K** **ALLOW ECF** **3 marks max** *Example* $n(CH_4 \bullet 5.74\,H_2O)$ = 8.375 ✓ $V = \frac{8.375 \times 8.314 \times 298}{101 \times 10^3}$ → 205 (dm^3) ✓✓ **Use of 24.0 dm^3 OR 22.4 dm^3** **ALLOW ECF** from $n(CH_4)$ **2 marks max for $n(CH_4)$ and V in dm^3** *24.0 dm^3* $n(CH_4 \bullet 5.74\,H_2O)$ = 8.375 ✓ V = 8.375 × 24.0 = 201 (dm^3) ✓ *22.4 dm^3* $n(CH_4 \bullet 5.74\,H_2O)$ = 8.375 ✓ V = 8.375 × 22.4 = 188 (dm^3) ✓ **13.4% (13.4/100) omitted** **3 marks** $n = \frac{1 \times 10^3}{16}$ = 62.5 (mol) ✗ $V = \frac{62.5 \times 8.314 \times 273}{101 \times 10^3}$ → 1400 (dm^3) ✓✓✓			
(e)	For fuel **OR** energy ✓	**1**		**ALLOW** responses linked with energy. e.g. • to generate electricity

Mark Scheme

Question			Answer	Marks		Guidance
						• for burning/heat **ALLOW** (chemical) feedstock **IGNORE** cooking
			Total	**11**		

Mark Scheme

Question	Answer	Marks	AO element	Guidance
5	**C**	**1**	AO1.2	

Mark Scheme

Question			Answer	Marks	Guidance
6	(a)	(i)	Hydrogen/H ✓	1	**ALLOW** H_2
		(ii)	Helium/He ✓	1	
		(iii)	Magnesium/Mg ✓	1	
		(iv)	Sulfur/S ✓	1	**ALLOW** sulphur; S_8
		(v)	Chlorine/C*l* **OR** fluorine/F ✓	1	**ALLOW** Cl_2 OR F_2
		(vi)	Phosphorus/P ✓	1	**ALLOW** P_4
		(vii)	Carbon/C ✓	1	**ALLOW** silicon/Si
		(viii)	Oxygen/O ✓	1	**ALLOW** O_2

Mark Scheme

Question	Answer	Marks	Guidance
(b)	**NaC*l* OR MgCl_2** **2 marks** Giant **ionic OR ionic** lattice ✓ **Ions** are **mobile** in **liquid** state ✓ --- **SiCl_4 OR PCl_3 OR SCl_2** **2 marks** (Simple) molecular **OR** simple covalent (lattice) ✓ Induced dipole(–dipole) forces/interactions **OR** London forces ✓ --- **Comparison of bond strengths** **1 mark** • Ionic bonds are stronger than London forces **OR** • Ionic bonds need more energy to break than London forces ✓	5	**IGNORE** aqueous/dissolved ions are mobile **IGNORE** 'free ions' **AND** 'ions are free to carry current' --- **ALLOW** 'are molecules' **IGNORE** • permanent dipole(–dipole) forces • IDID and LDF • van der Waals --- **ALLOW** attraction between ions for ionic bonds **ALLOW** intermolecular forces for London forces **ALLOW** overcome for break **ALLOW** indirect comparison, i.e. • Ionic bonds are strong **AND** London forces are weak **OR** • Ionic bonds need a large amount of energy to break **AND** London forces need little energy to break
	Total	**13**	

Mark Schemes

Question	Answer	Marks	AO element	Guidance
7	**A**	**1**	AO1.1	

Mark Scheme

Question			Answer	Marks	AO element	Guidance
8	(a)		**Polar bonds** F (atom) is more electronegative (than C atom) **OR** F is very/the most electronegative ✓ **No overall dipole** (CF_4 is) symmetrical **OR** tetrahedral **OR dipoles** cancel **OR dipoles** act in opposite directions ✓	**2**	AO1.1 ×2	**Mark independently** **ALLOW** C and F have **different** electronegativities **OR** the atoms have different electronegativities **……BUT** **DO NOT ALLOW** C is more electronegative **ALLOW** C–F shown with correct dipole, i.e. $C^{\delta+}–F^{\delta–}$. **IGNORE** square planar **IGNORE** polar **bonds** cancel **BUT ALLOW** polarities cancel **IGNORE** charges cancel
	(b)		(Molecules) contain • ^2H **OR** deuterium/D • ^3H **OR** tritium/T **OR** O/H atoms have more neutrons (than ^1H) **OR** (different) O/H isotopes are present **OR** (Molecules are) D_2O ✓	**1**	AO1.2	**ALLOW** Molecules contain ^{18}O Idea of **isotopes** is critical **……..BUT** **DO NOT ALLOW** isotopes of elements different from H and O (e.g. C)
	(c)		$p(O_2) = 0.21 \times 1.00 \times 10^5$ = **21,000 / 2.1 × 10^4** (Pa) ✓	**1**	AO2.2	

Mark Scheme

Question	Answer	Marks	AO element	Guidance
(d)	**FIRST, CHECK ANSWER** **IF** answer = **231 000,** award **2 marks** --- ***n*(C$_3$H$_8$)** $n(C_3H_8) = \frac{42.0 \times 10^3}{24.0}$ **OR** $\frac{42.0 \times 10^6}{24\,000}$ **OR** 1750 (mol) ✓ **Mass of CO$_2$** mass CO$_2$ = 3 × 1750 × 44 = **231 000 / 2.31 × 10^5** (g) ✓ **ALLOW 2 SF**, e.g. 230 000	**2**	AO2.2 AO2.6	**ALLOW** use of ideal gas equation with a sensible temperature (20–25ºC) and pressure (100/101 kPa) At 20ºC and 100 kPa, $n(C_3H_8) = \frac{100 \times 10^3 \times 42.0}{8.314 \times 293}$ = 1724… (mol) → ~ 227586 (g) (dependent on roundings) At 25ºC and 100 kPa, $n(C_3H_8) = \frac{100 \times 10^3 \times 42.0}{8.314 \times 298}$ = 1695… (mol) → ~ 223767 (g) (dependent on roundings) **ALLOW** use of 8.31 for *R* **ALLOW ECF** from *n*(C$_3$H$_8$) --- **Common errors from 24.0 dm^3** 231 → 1 mark *No conversion of m^3 to dm^3* 0.231 → 1 mark *Confusion of cm^3 and dm^3* 77 000 → 1 mark *No 3 × for CO$_2$*
(e)	Initial rate = $10^{-2} \times 2.4 \times 10^{-3}$ s^{-1} = **2.4 × 10^{-5}** (mol dm^{-3} s^{-1}) ✓	**1**	AO2.2	
(f)	**FIRST, CHECK ANSWER** **IF** answer = **9.03 × 10^{22},** award **2 marks** --- $n(P_2O_5) = \frac{4.26}{142.0}$ **OR** 0.03(00) (mol) ✓ O atoms = 5 × 0.0300 × 6.02 × 10^{23} = **9.03 × 10^{22}** ✓ Minimum 3 SF required	**2**	AO2.2	**Alternative approach** $n(\text{O atoms}) = \frac{4.26}{142.0} \times 5 = 0.15$ ✓ O atoms = 0.15 × 6.02 × 10^{23} = 9.03 × 10^{22} ✓ **ALLOW ECF** from incorrect *n*(P$_2$O$_5$) **ALLOW** use of 6.022 × 10^{23} --- **Common error** 1.806 × 10^{22} **OR** 1.81 × 10^{22} → 1 mark No × 5
	Total	**9**		

Mark Scheme

Question			Answer	Marks	AO element	Guidance
9	(a)	(i)	$4Pb_2O_3 + 3CH_4 \rightarrow 8Pb + 3CO_2 + 6H_2O$ **OR** $Pb_2O_3 + CH_4 \rightarrow 2Pb + CO + 2H_2O$ **OR** $2Pb_2O_3 + 3CH_4 \rightarrow 4Pb + 3C + 6H_2O$ ✓	1	AO2.6	**ALLOW** multiples **IGNORE** state symbols
		(ii)	**ONE Safety issue AND precaution** ✓ **From:** **Safety issue:** Compounds may be toxic/poisonous/flammable **AND** **Precaution**: Use a fume cupboard/good ventilation **----------** **Safety issue:** Lead (compounds) is/are toxic/poisonous **AND** **Precaution**: Wear gloves **----------** **Safety issue:** Methane is flammable **AND** **Precaution**: Keep away from flame **----------**	1	AO3.3	**IGNORE** use safety glasses, lab coat (*in question)* and tying hair back, safety screen Definite safety issue needed. Not just 'harmful' **OR** dangerous (Too vague). **FOR OTHER SAFETY ISSUES AND PRECAUTIONS, CONTACT TEAM LEADER**

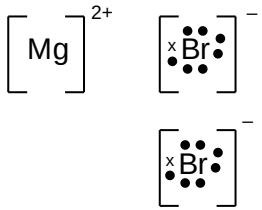
Mark Scheme

Question			Answer	Marks	AO element	Guidance
		(iii)	Any 2 modifications ✓ ✓ from **1.** Heat to constant mass (Ensures all lead oxide has reacted) **2.** Spread/stir/break up lead oxide **OR** increase surface area **OR** use powder rather than lumps (Ensures all lead oxide has reacted) **3.** Pass methane/inert gas/N_2 through tube as it cools **OR** don't pass cold air (Prevents O_2 reacting with Pb) **4.** Use excess methane **OR** more methane (Ensures all lead oxide has reacted) **5.** Bubble (escaping) gas through lime water (Ensures all lead oxide has reacted **OR** ensures all CO_2 has been produced)	**2**	AO3.4 ×2	**ALLOW** response that implies heating to constant mass, e.g. Heat again until the mass does not change **IGNORE** 'heat for longer' *Needs link to constant mass* **IGNORE** 'weigh straight after heating' **IGNORE** idea of repeating the experiment/ taking an average/ getting concordant results / larger sample size, etc.
		(iv)	Pb : O Masses(/g): 3.132 **AND** 0.322 **OR** Mole ratios: $\frac{\mathbf{3.132}}{207.2} : \frac{\mathbf{0.322}}{16.0}$ **OR** Mole ratios: 0.0151: 0.020125 ✓ Empirical formula Pb_3O_4 (must come from masses) ✓	**2**	AO2.8 ×2	**NO ECF** from incorrect masses

Mark Scheme

Question	Answer	Marks	AO element	Guidance
(b)	**Type of lattice 2 marks** • **SiO_2**: Giant (covalent lattice) ✓ • **CO_2**: Simple molecular/covalent (lattice) ✓ **----------** **Explanation 2 marks** **1. Forces in CO_2** • Induced dipole–dipole interactions / London forces ✓ **2. Comparison of forces with strength / melting point** • (Covalent) bonds in SiO_2 are stronger **THAN intermolecular** forces in CO_2 **OR** • More energy to break (covalent) bonds in SiO_2 **THAN intermolecular** forces in CO_2 ✓ **ORA**	**4**	AO1.1 ×2 AO1.1 ×1 AO2.1 ×1	**Throughout, IGNORE** 'ionic' for SiO_2 **FOR SiO_2, IGNORE** macromolecular **DO NOT ALLOW** giant **metallic** Mark explanation independently on type of lattice i.e. no **ECF** from incorrect lattice For CO_2 **IGNORE** • covalent bonds • van der Waals' forces • idid • LDF **DO NOT ALLOW** hydrogen bonds **OR** permanent dipole interactions For SiO_2, comparison needs just 'bonds' **OR** 'forces' For intermolecular, **ALLOW** 'between molecules' For comparison, **ALLOW** strong in SiO_2 **AND** weak in CO_2 **DO NOT ALLOW** responses containing intermolecular forces in SiO_2 **IGNORE** 'More bonds'
	Total	**10**		

Mark Scheme

Question			Answer	Marks	AO element	Guidance
10	(a)		(The mean/average mass) taking into account the relative abundancies of the isotopes ✓	1	1.1	**ALLOW** sum of (isotopic mass × %abundance) sum of (isotopic mass × abundance) / total abundance **DO NOT ALLOW** average mass of the isotopes
		(i)	 Mg with no (or 8) outer electrons **AND** 2 × Br with '*dot-and-cross*' outer octet ✓ Correct charges ✓	2	1.2 2.5	**ALLOW** 8 electrons in Mg^{2+} **BUT** 'extra' electron in Br^- must match symbol for electrons in Mg^{2+} **IGNORE** inner shells and circles **ALLOW** 1 mark if both electron arrangements and charges are correct but only one Br is drawn. **ALLOW** $2[Br^-]$, $2[Br]^-$ (brackets not required)
		(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1.71×10^{22} award 3 marks** --- $n(MgBr_2) = \frac{1.74}{184.1} = 0.00945\ldots..$ mol ✓ Moles of ions = 0.00945…. × 3 = 0.0283…. mol ✓ Number of ions = 0.0283... × 6.02×10^{23} = 1.71×10^{22} ✓ **3SF** required	3	2.2×3	**ALLOW ECF** Calculator answer = $9.451385117 \times 10^{-3}$ **ALLOW ECF** from incorrect moles of ions. e.g. 0.00945 Common error 5.69×10^{21} no × 3 2 marks

Mark Scheme

Question	Answer	Marks	AO element	Guidance
(c)*	*Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.* **Level 3 (5–6 marks)** Explains all three melting point values and conductivities in terms of structure, bonding, particles and relative strengths of the forces. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Attempts to explain all three melting point values and conductivities in terms of the structure, bonding, particles of all three substances, but explanations may be incomplete or may contain only some correct statements or comparisons. **OR** Correctly explains two of the melting point values and conductivities in terms of the structure, bonding, particles. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Identifies only some of the structures, forces and particles **AND** Attempts to explain the melting point values **OR** conductivities in terms of the structure, bonding, particles *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	**6**	1.1×3 2.1×3	**Indicative scientific points may include:** **<u>Structure and bonding</u>** **Magnesium** • Structure: giant lattice • Metallic bonding • **Delocalised** electrons **Bromine** • Structure: simple molecular • induced dipole dipole forces **(**London forces) • (Between) molecules **DO NOT ALLOW** (between) atoms **Magnesium bromide** • Structure: giant lattice • Ionic bonding • (Between) oppositely charged ions **<u>Comparison of bond strengths</u>** • Metallic and ionic bonds are stronger than London forces **OR** Metallic and Ionic bonds need more energy to break than London forces **<u>Conductivity</u>** • Magnesium: conducts due to delocalised electrons can move/mobile. **IGNORE** 'Carry' charge for movement • Magnesium bromide: In solid IONS cannot move; in solution IONS can move. **DO NOT ALLOW** electrons. • Bromine: Does not conduct as no mobile charge carriers.

Mark Scheme

Question			Answer	Marks	AO element	Guidance
	(d)	(i)	$Mg^{2+}(g) + 2Br(g) + 2e^{-}$ ✓ $Mg(s) + Br_2(l)$ ✓	2	1.2× 2	State symbols required. **CARE:** Liquid state symbol for Br_2
		(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = –346.5 award 2 marks** --- $2\Delta H$ hyd = – 525 – 186 – (2 x 112) – 148 – 736 – 1450 + (2 x -325) + 1926 **OR** – 525 – 186 – 224 – 148 – 736 – 1450 + 650 + 1926 **OR** = – 693 ✓ ΔH hyd = –346.5 (kJ mol^{-1}) ✓	2	2.2×2	**ALLOW -347** (kJ mol^{-1}) for 2 marks. **ALLOW** for 1 mark **ONE** error with sign **OR** use of 2: –693 (not divided by 2 at the end) 346.5 (wrong sign on answer) **Common errors for 1 mark** –2272.5 (–1926 instead of 1926) -1386 (**2** x -693 instead of -693) –996.5 (–650 instead of 650) –509 (**2** × 325 not used) –290.5 (**2** × 112 not used) –198.5 (148 instead of –148) –160.5 (186 instead of –186) –122.5 (224 instead of –224) 178.5 (525 instead of –525) 389.5 (736 instead of –736) 1103.5 (1450 instead of –1450) **For other answers**, check for a **single** transcription error or calculation error which could merit 1 mark **DO NOT ALLOW** any answer which involves two errors e.g. –453 (**2** × 325 not used **AND 2 x** 112 not used)

Mark Scheme

Question			Answer	Marks	AO element	Guidance
		(iii)	**Equation:** $Mg^{2+}(g) + 2Br^{-}(g) \rightarrow MgBr_2(s)$ ✓ **CHECK THE ANSWER ON ANSWER LINE** **If answer = –2433 award 2 marks** --- Lattice enthalpy = $\Delta_{hy}H(Mg^{2+}) + 2 \times \Delta_{hy}H(Br^{-}) - \Delta_{sol}H(MgBr_2)$ **OR** -1926 + (2 x -346.5) – (-186) **OR** $\Delta_fH(MgBr_2) - 2\Delta_{at}H(Br) - \Delta_{at}H(Mg)$ – 1st IE(Mg) – 2nd IE(Mg) – $2\Delta_{ea}H(Br)$ **OR** -525 – (2 x 112) – 148 – 736 – 1450 – (2 x -325) ✓ **Lattice enthalpy** = –2433 kJ mol^{-1} ✓	**3**	1.2 2.2 x 2	State symbols required **For other answers**, check for a **single** transcription error or calculation error which could merit 1 mark **DO NOT ALLOW** any answer which involves two errors **ALLOW ECF** from incorrect answer to d(ii)
			Total	**18**		

Mark Scheme

Question	Answer	Marks	AO element	Guidance
11	B	1	1.1	

Mark Scheme

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO element</th><th>Guidance</th></tr>
<tr><td>12</td><td>(a)</td><td></td><td>
<table>
<tr><th>Bond angle</th><th>Name of shape</th></tr>
<tr><td>120(°)</td><td>Trigonal planar</td></tr>
<tr><td>104–105(°)</td><td>Non-linear</td></tr>
</table>
Mark by row OR by column to give higher mark

i.e. 2 bond angles correct ✓
2 shapes correct ✓
OR
i.e. bond angle AND shape correct in 1st row ✓
bond angle AND shape correct in 2nd row ✓
</td><td>2</td><td>1.2×2</td><td>For non-linear,
ALLOW bent, v-shaped, angular
IGNORE planar, ‘not straight’</td></tr>
<tr><td></td><td>(b)</td><td></td><td>
$CH_3SO_2OH + H_2O \rightleftharpoons CH_3SO_2O^- + H_3O^+$ ✓

A1 B2 B1 A2 ✓

For an equilibrium shown using CH_3COOH instead of H_2O, mark acid–base pairs by ECF, i.e.
$CH_3SO_2OH + CH_3COOH \rightleftharpoons CH_3SO_2O^- + CH_3COOH_2^+$ ☒
A1 B2 B1 A2 ECF ✓

CH_3SO_2OH dissociates more (than CH_3COOH)
OR CH_3SO_2OH is a stronger acid ✓

ORA in terms of CH_3COOH being a weaker acid

Student is correct
AND
(sulfonic acid has) lower pK_a/higher K_a OR greater $[H^+]$
ORA ✓
</td><td>4</td><td>2.1×2

3.1

3.2</td><td>ALLOW → for ⇌

ALLOW acid–base pairs labelled other way round.
i.e. $CH_3SO_2OH + H_2O \rightleftharpoons CH_3SO_2O^- + H_3O^+$
A2 B1 B2 A1
ALLOW ~~small slip~~

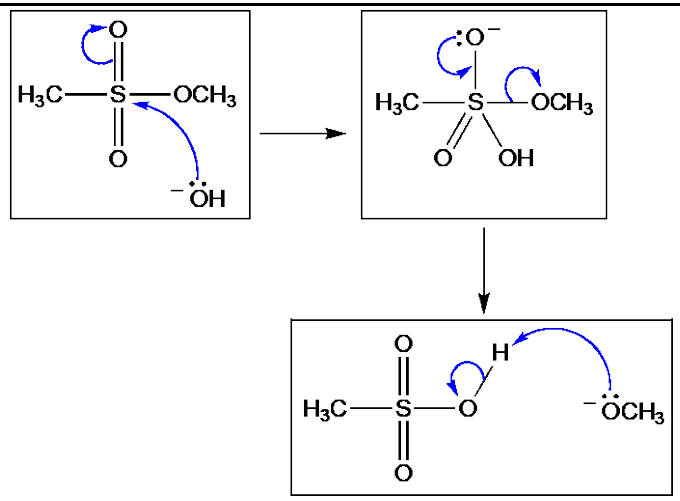
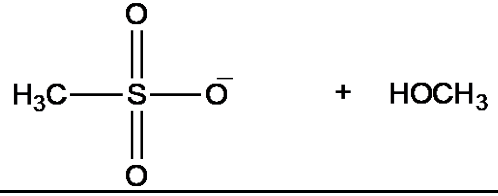
If ONE charge is missing from equilibrium.
ALLOW ECF for acid–base pairs mark

IGNORE ‘more acidic’
Response needs strength/dissociation

ALLOW maths explanation for final 2 marks, e.g.
$K_a(CH_3COOH) = 10^{-(4.76)} = 1.74 \times 10^{-5}$
$[H^+] = \sqrt{(1.74 \times 10^{-5}) \times 1)} = 4.17 \times 10^{-3}$
$pH = -\log 4.17 \times 10^{-3} = 2.38$ ✓

$K_a(CH_3SO_2OH) = 10^{-(-1.90)} = 79.4$
$[H^+] = \sqrt{(79.4) \times 1)} = 8.91$
$pH = -\log 8.91 = -0.95$ ✓
BOTH pH calcs subsumes ‘Student is correct’</td></tr>
</table>

Mark Scheme

Question			Answer	Marks	AO element	Guidance
	(c)		 6 curly arrows correct ✓✓✓✓ 5 curly arrows correct ✓✓✓ 4 curly arrows correct ✓✓ 3 curly arrows correct ✓	4	3.1×4	**IGNORE** any added charges **OR** dipoles. *Marks solely for curly arrows* **IGNORE** any curly arrows on bottom structures (not in boxes): 
			Total	**10**		