Markscheme

May 2018

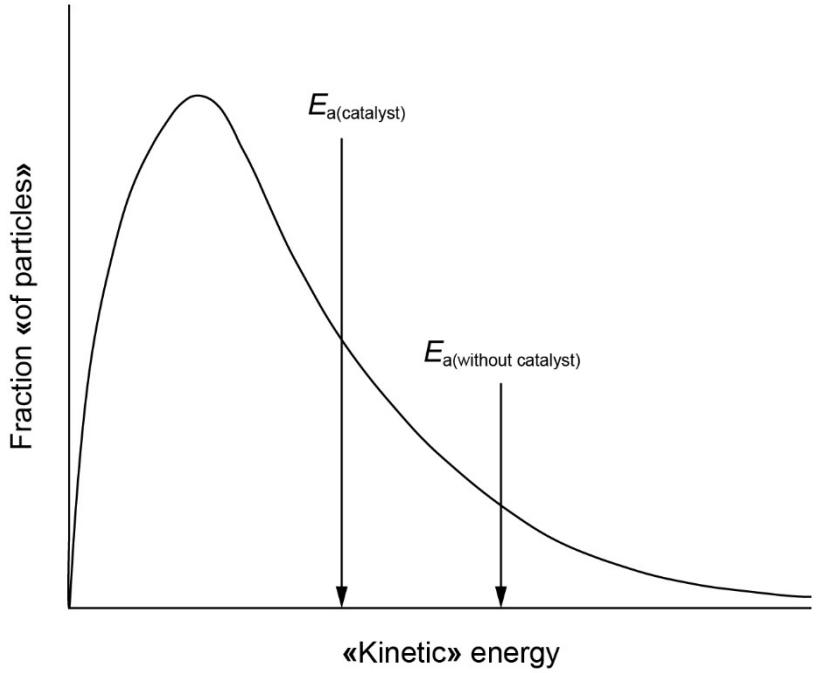
Chemistry

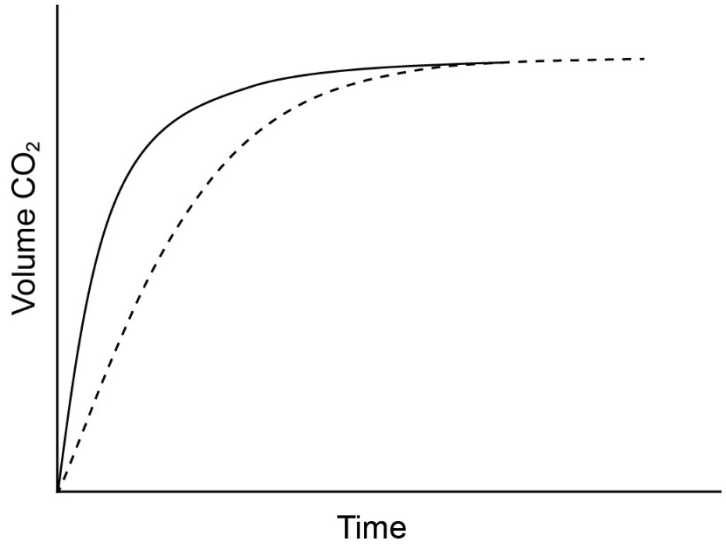
Standard level

Paper 2

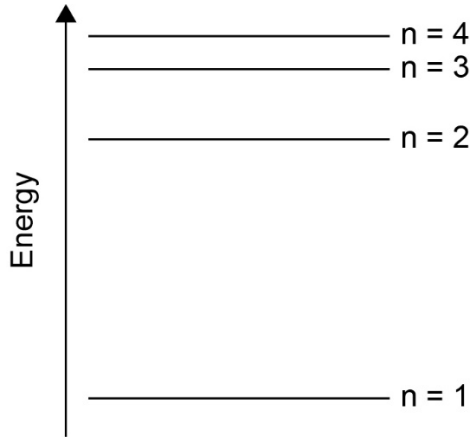
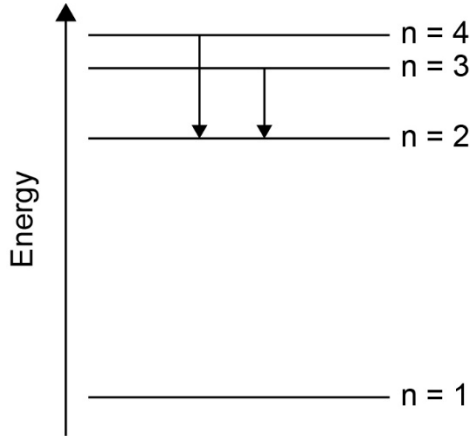
13 pages

Question			Answers	Notes	Total
1.	a		$n(H_2SO_4)$ «= 0.0500 dm^3 × 0.100 mol dm^{-3}» = 0.00500/5.00 × 10^{-3}«mol» ✓		1
1.	b		$H_2SO_4\,(aq) + Mg(OH)_2\,(s) \rightarrow MgSO_4\,(aq) + 2H_2O\,(l)$ ✓	*Accept an ionic equation.*	1
1.	c		«$n(H_2SO_4) = \frac{1}{2} \times n(NaOH) = \frac{1}{2}$ (0.02080 dm^3 × 0.1133 mol dm^{-3})» 0.001178/1.178 × 10^{-3} «mol» ✓		1
1.	d		$n(H_2SO_4)$ reacted «= 0.00500 – 0.001178» = 0.00382/3.82 × 10^{-3} «mol» ✓		1
1.	e		$n(Mg(OH)_2)$ «= $n(H_2SO_4)$ =» = 0.00382/3.82 × 10^{-3} «mol» ✓ $m(Mg(OH)_2)$ «= 0.00382 mol × 58.33 g mol^{-1}» = 0.223 «g» ✓	*Award **[2]** for correct final answer.*	2
1.	f		% $Mg(OH)_2$ «= $\frac{0.223\ g}{1.24\ g} \times 100$» = 18.0 «%» ✓	*Answer must show three significant figures.*	1

Question			Answers	Notes	Total
2.	a		 both axes correctly labelled ✓ correct shape of curve starting at origin ✓ $E_{a(catalyst)} < E_{a(without\ catalyst)}$ on x-axis ✓	*M1:* *Accept "speed" for x-axis label.* *Accept "number of particles", "N", "frequency" or "probability **«**density**»**" for y-axis label.* *Do **not** accept "potential energy" for x-axis label.* *M2:* *Do **not** accept a curve that touches the x-axis at high energy.* *Do **not** award M2 if two curves are drawn.* *M3:* *Ignore any shading under the curve.*	**3**

Question			Answers	Notes	Total
2.	b	i	 curve starting from origin with steeper gradient ***AND*** reaching same maximum volume ✓		1
2.	b	ii	rate decreases ***OR*** slower reaction ✓ **«**ethanoic acid**»** partially dissociated/ionized **«**in solution/water**»** ***OR*** lower $[H^+]$ ✓	*Accept "weak acid" or "higher pH*".	2

Question			Answers	Notes	Total
2.	c		«pH» converts «wide range of $[H^+]$» into simple «log» scale/numbers ***OR*** «pH» avoids need for exponential/scientific notation ***OR*** «pH» converts small numbers into values «typically» between 0/1 and 14 ***OR*** «pH» allows easy comparison of values of $[H^+]$ ✓	*Accept "uses values between 0/1 and 14".* *Do **not** accept "easier to use".* *Do **not** accept "easier for calculations".*	1
2.	d		«species» do not differ by a «single» proton/H^+ ***OR*** conjugate base of H_3PO_4 is $H_2PO_4^-$ «not HPO_4^{2-}» ***OR*** conjugate acid of HPO_4^{2-} is $H_2PO_4^-$ «not H_3PO_4» ✓	*Do **not** accept "hydrogen/H" for "H^+/proton".*	1

Question			Answers	Notes	Total
3.	a	i	 4 levels showing convergence at higher energy ✓		1
3.	a	ii	 arrows (pointing down) from n = 3 to n = 2 ***AND*** n = 4 to n = 2 ✓		1

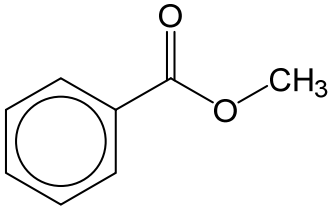
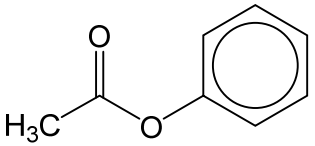
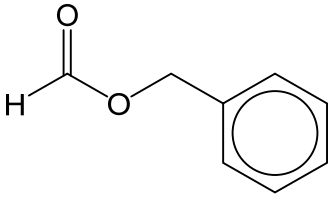
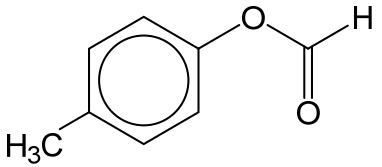
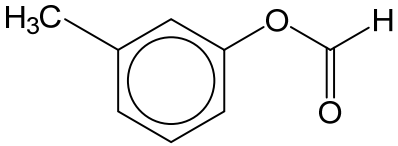
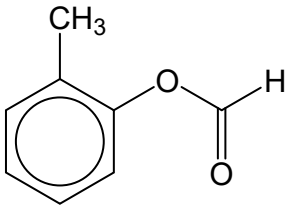
Question			Answers	Notes	Total
3.	b	i	same number of shells/«outer» energy level/shielding ***AND*** nuclear charge/number of protons/Z_{eff} increases «causing a stronger pull on the outer electrons» ✓		1
3.	b	ii	K^+ 19 protons ***AND*** Cl^- 17 protons ***OR*** K^+ has «two» more protons ✓ same number of electrons/isoelectronic «thus pulled closer together» ✓		2
3.	c	i			1
3.	c	ii	*Anode (positive electrode):* $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ ✓ *Cathode (negative electrode):* $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ ✓	*Accept* $Cu(s) - 2e^- \rightarrow Cu^{2+}(aq)$. *Accept* $\rightleftharpoons$ *for* $\rightarrow$. *Award* ***[1 max]*** *if the equations are at the wrong electrodes.*	2
3.	c	iii	«external» circuit/wire ***AND*** from positive/anode to negative/cathode electrode ✓	*Accept "through power supply/battery" instead of "circuit".*	1

Question			Answers	Notes	Total
4.	a		*bonds broken:* 4(C–H) + 2(H–O) / 4(414) + 2(463) / 2582 **«**kJ**»** ✓ *bonds made:* 3(H–H) + C≡O / 3(436) + 1077 / 2385 **«**kJ**»** ✓ ΔH **«**= $\sum BE_{(\text{bonds broken})} - \sum BE_{(\text{bonds made})}$ = 2582 – 2385**»** = **«**+**»** 197 **«**kJ**»** ✓	*Award **[3]** for correct final answer.* *Award **[2 max]** for –197 **«**kJ**».***	**3**
4.	b	i	$\Delta H_f^\ominus$ for any element = 0 **«**by definition**»** ***OR*** no energy required to form an element **«**in its stable form**»** from itself ✓		**1**
4.	b	ii	$\Delta H^\ominus$ **«** = $\sum \Delta H_{f\,(\text{products})}^\ominus - \sum \Delta H_{f\,(\text{reactants})}^\ominus = -111 + 0 - [-74.0 + (-242)]$**»** = **«**+**»** 205 **«**kJ**»** ✓		**1**
4.	b	iii	**«**bond enthalpies**»** averaged values **«**over similar compounds**»** ***OR*** **«**bond enthalpies**»** are not specific to these compounds ✓		**1**
5.	a		*Q*: non-equilibrium concentrations ***AND*** K_c: equilibrium concentrations ***OR*** Q: «measured» at any time ***AND*** K_c: «measured» at equilibrium ✓		**1**
5.	b		**«**$Q = \frac{[SO_3]^2}{[SO_2]^2[O_2]} = \frac{1.00^2}{1.00^2 \times 2.00}$**»** = 0.500 ✓ reverse reaction favoured/reaction proceeds to the left ***AND*** $Q > K_c$/0.500 > 0.282 ✓	*Do **not** award M2 without M1.*	**2**

Question			Answers	Notes	Total
6.	a	i	polar bonds «between H and group 16 element» ***OR*** difference in electronegativities «between H and group 16 element» ✓ uneven distribution of charge/electron cloud ***OR*** non-linear/bent/V-shaped/angular shape «due to lone pairs» ***OR*** polar bonds/dipoles do not cancel out ✓	*M2:* *Do **not** accept "net/overall dipole moment" without further explanation.* *Accept "non-symmetrical «shape/distribution of charge»".*	**2**
6.	a	ii	number of electrons increases ✓ London/dispersion/instantaneous induced dipole-induced dipole forces increase ✓	*M1: Accept "M_r/A_r increases" or "molecules become larger in size/mass/surface area".*	**2**
6.	b		*Electron domain geometry:* tetrahedral ✓ *Molecular geometry:* bent/V-shaped/angular ✓	*Both marks can be awarded for clear diagrams. Electron domain geometry requires a 3-D diagram showing the tetrahedral arrangement.*	**2**

Question			Answers	Notes	Total
7.	a		*Physical evidence:* equal C–C bond «lengths/strengths» ***OR*** regular hexagon ***OR*** **«**all**»** C–C have bond order of 1.5 ***OR*** «all» C–C intermediate between single and double bonds ✓ *Chemical evidence:* undergoes substitution reaction **«**more readily than addition**»** ***OR*** does not discolour/react with bromine water ***OR*** substitution forms only one isomer for 1,2-disubstitution **«**presence of alternate double bonds would form two isomers**»** ***OR*** more stable than expected **«**compared to hypothetical molecule cyclohexa-1,3,5-triene**»** ***OR*** enthalpy change of hydrogenation/combustion is less exothermic than predicted **«**for cyclohexa-1,3,5-triene**»** ✓	*M1:* *Accept "all C–C–C bond angles are equal".*	**2**

Question			Answers	Notes	Total
7.	b	i	$3CH_3CH_2CH_2OH\,(l) + Cr_2O_7^{2-}\,(aq) + 8H^+\,(aq) \rightarrow 3CH_3CH_2CHO\,(aq) + 2Cr^{3+}\,(aq) + 7H_2O\,(l)$ correct reactants and products ✓ balanced equation ✓		2
7.	b	ii	*Aldehyde:* by distillation **«**removed from reaction mixture as soon as formed**»** ✓ *Carboxylic acid:* **«**heat mixture under**»** reflux **«**to achieve complete oxidation to –COOH**»** ✓	*Accept clear diagrams or descriptions of the processes.*	2
7.	c	i	**«** $\frac{136}{48+4+16} = 2$ **»** $C_8H_8O_2$ ✓		1
7.	c	ii	A: C–H **«**in alkanes, alkenes, arenes**»** ***AND*** B: C=O **«**in aldehydes, ketones, carboxylic acids and esters**»** ✓		1

Question			Answers	Notes	Total
7.	**c**	**iii**	*Any two of:*  ***OR*** $C_6H_5COOCH_3$ ✓  ***OR*** $CH_3COOC_6H_5$ ✓  ***OR*** $HCOOCH_2C_6H_5$ ✓	*Do **not** penalize use of Kekule structures for the phenyl group.* *Accept the following structures:*    *Award **[1 max]** for two correct aliphatic/linear esters with the molecular formula $C_8H_8O_2$.*	**2**
7.	**c**	**iv**	$C_6H_5COOCH_3$ **«**signal at 4 ppm (3.7 – 4.8 range in data table) due to alkyl group on ester**»** ✓		**1**