CAMBRIDGE INTERNATIONAL AS & A LEVEL CHEMISTRY · 9701

CHEMISTRY



MARK SCHEME

7 EQUILIBRIA

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Paper 1 Multiple Choice Answers: Equilibria

Question	Paper	Q. No.	Answer
337	9701_m22_qp_12	12	A
338	9701_m22_qp_12	24	C
339	9701_s21_qp_11	10	D
340	9701_s21_qp_12	10	B
341	9701_s21_qp_13	9	D
342	9701_s21_qp_13	10	A
343	9701_s21_qp_13	11	D
344	9701_w21_qp_11	10	B
345	9701_m20_qp_12	6	A
346	9701_m20_qp_12	11	B
347	9701_s20_qp_11	1	A
348	9701_s20_qp_11	7	B
349	9701_s20_qp_12	3	C
350	9701_s20_qp_12	11	D
351	9701_s20_qp_13	11	B
352	9701_w20_qp_11	10	C
353	9701_w20_qp_12	10	B
354	9701_w20_qp_12	11	C
355	9701_w20_qp_12	14	B
356	9701_m19_qp_12	11	C
357	9701_s19_qp_11	10	C
358	9701_s19_qp_11	11	D
359	9701_s19_qp_12	10	C
360	9701_s19_qp_13	9	B
361	9701_s19_qp_13	10	A
362	9701_w19_qp_11	10	C
363	9701_w19_qp_11	11	A
364	9701_w19_qp_12	10	C
365	9701_m18_qp_12	13	A
366	9701_m18_qp_12	14	B
367	9701_s18_qp_12	5	B
368	9701_s18_qp_12	10	A
369	9701_s18_qp_13	9	C
370	9701_s18_qp_13	10	D
371	9701_s18_qp_13	17	C
372	9701_s18_qp_13	18	B
373	9701_w18_qp_11	9	D
374	9701_w18_qp_11	10	D
375	9701_w18_qp_12	9	D
376	9701_m17_qp_12	3	D
377	9701_m17_qp_12	11	D
378	9701_s17_qp_11	10	C
379	9701_s17_qp_12	9	A
380	9701_s17_qp_12	10	A
381	9701_s17_qp_13	9	A
382	9701_s17_qp_13	10	B

Paper 1 Multiple Choice Answers: Equilibria (continued)

Question	Paper	Q. No.	Answer
383	9701_w17_qp_11	9	D
384	9701_w17_qp_12	9	C
385	9701_m16_qp_12	11	C
386	9701_s16_qp_11	9	D
387	9701_s16_qp_11	10	D
388	9701_s16_qp_12	10	C
389	9701_s16_qp_13	9	C
390	9701_s16_qp_13	11	D
391	9701_w16_qp_11	10	A
392	9701_w16_qp_12	10	A
393	9701_w16_qp_12	11	A
394	9701_s15_qp_11	6	B
395	9701_s15_qp_11	9	A
396	9701_s15_qp_12	8	B
397	9701_s15_qp_12	9	A
398	9701_w15_qp_11	2	A
399	9701_w15_qp_11	10	B
400	9701_w15_qp_12	8	C
401	9701_w15_qp_12	9	B
402	9701_m22_qp_12	13	B
403	9701_m21_qp_12	9	B
404	9701_w21_qp_11	7	B
405	9701_s20_qp_13	6	D
406	9701_m18_qp_12	15	B
407	9701_s18_qp_11	15	B
408	9701_s16_qp_13	10	A
409	9701_s15_qp_11	8	C

26. 9701_s21_ms_23 Q: 2

Question	Answer	Marks
(a)	**M1** H-bond between an O and an H in OH groups in water and methanol molecules	1
	M2 minimum three partial charges (in sequence) over one water and one methanol molecule, *i.e.*:	1
	M3 either $^{\delta-}$O—H$^{\delta+}$- - - -$^{\delta-}$O or H$^{\delta+}$- - - -$^{\delta-}$O—H$^{\delta+}$ lone pair of electrons on O of H-bond, in line with H-bond	1
(b)(i)	**M1** (methanol) gas (particles / molecules) in equilibrium with liquid	1
	M2 (methanol) gas (particles) exert a pressure (on the walls of a container / on the surface of the liquid)	1
(b)(ii)	(liquid) particles (at the surface) have enough energy (to overcome attractive forces / evaporate / to become a vapour)	1
(b)(iii)	**M1** (liquid) H_2O molecules are held by stronger **hydrogen bonding** **OR** it takes more energy to break the **hydrogen bonds** between water molecules (in the liquid state) **OR** each water molecule forms two **hydrogen bonds** (whereas methanol can (only) form one per molecule	1
	M2 fewer H_2O liquid molecules (able to) escape / become gaseous **ora**	1
(c)(i)	**M1** rates of forward and reverse / backward reactions are equal	1
	M2 closed / sealed system / container OR no change in measurable properties / no change in macroscopic properties	1
(c)(ii)	**M1** mol fraction = 0.97 / (0.030 + 0.060 + 0.97) = 0.97 / 1.06 = (0.9151)	1
	M2 M1 $\times$ 1.0 $\times$ 10^7 = 9.2 $\times$ 10^6 (Pa) ✓✓	1
(c)(iii)	*expression for* K_p **M1** $K_p = p(CH_3OH) / p(CO) \times p(H_2)^2$	1
	M2 units = Pa^{-2}	1

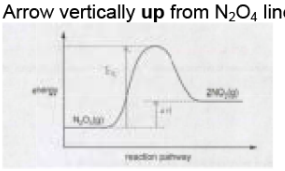
27. 9701_s18_ms_23 Q: 1

(a)	  trigonal planar non-linear/bent/V-shaped/angular	**4**
(b)(i)	stronger attraction for O^{2-} / stronger ionic bonding / more energy needed to overcome ionic bonding / separate ions	**1**
	charge density of magnesium (ion) is greater (than sodium ion) ***ora***	**1**
(b)(ii)	Either: M1 SiO_2 has a giant (covalent) structure / giant molecular M2 Covalent bonds (much) stronger than VdW / id-id / IMFs in SO_3 OR M1 SO_3 has a (simple) molecular structure / (simple) molecule. M2 VdW / id-id / IMFs M2 IMF's are (much) weaker than covalent bonds (broken in SiO_2) OR M1 Covalent bonds are broken in SiO_2 AND VdW / id-id / IMFs in SO_3 M2 Covalent bonds are stronger (than VdW / id-id / IMFs)	**2**
(c)(i)	molecules / particles / reacting species are closer together	**1**
	so frequency of collisions increases	**1**
	few(er) moles on right	**1**
	so (equilibrium) reaction shifts right / towards products / (as pressure increases to oppose the change)	**1**
(c)(ii)	Decreasing reactant concentrations (at different time intervals / as reaction progresses)	**1**
	So rate decreases OR change in concentration ÷ time taken decreases	**1**
(c)(iii)	(line becomes horizontal when) forward and reverse rates equal / equilibrium established	**1**
(c)(iv)	2:1 ratio in equation / SO_2 used up more quickly (than O_2) / 2 × SO_2 react for every 1 × O_2	**1**
(d)(i)	$K_c = \frac{[SO_3]^2}{[SO_2]^2 \times [O_2]}$	**1**
(d)(ii)	SO_2 = 0.02 (mol)	**1**
	O_2 = 1.01 (mol)	**1**
(d)(iii)	$K_c = \frac{(1.98/40)^2}{(0.02/40)^2 (1.01/40)}$ M1 = 3.88 / 3.882 × 10^5 M2 Units = $dm^3\ mol^{-1}$ / $mol^{-1}\ dm^3$ M3	**3**

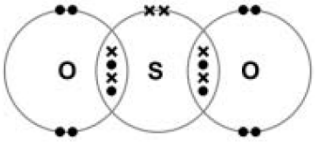
28. 9701_w17_ms_22 Q: 2

(a)	−444	1
(b)(i)	(higher rate / rate increases) due to higher frequency of successful collisions	1
	more molecules / particles with $E \geqslant E_a$	1
(b)(ii)	(percentage decomposition of PCl_5) increases	1
	(forward) reaction is endothermic	1
(c)	rates of forward and reverse / backward reactions are equal	1
	closed / sealed system/container	1
(d)(i)	n_{TOTAL} = 1.20 + 0.80 + 0.80 OR 2.80 (mol) **OR** mole fraction = 1.20 / 2.80 OR 0.429	1
	$pPCl_5$ = $1 \times 10^5 \times (1.20 / 2.80)$ = 4.29×10^4 (Pa)	1
(d)(ii)	$K_p = \frac{pPCl_3 \times pCl_2}{pPCl_5}$	1
(d)(iii)	1.91×10^4	1
	Pa	1

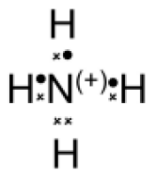
29. 9701_w16_ms_22 Q: 2

(a)	Arrow vertically **up** from N_2O_4 line to $2NO_2$ line labelled enthalpy change / ΔH Arrow vertically **up** from N_2O_4 line to dashed line from peak labelled activation energy / E_a 	1 1
(b)(i)	$M_r = \frac{m \times R \times T}{p \times V}$ $\left(= \frac{4.606 \times 8.31 \times 323}{1.68 \times 10^5 \times 1 \times 10^{-3}}\right)$ = 73.6	1 1
(b)(ii)	2n	1
(b)(iii)	0.05 – n + 2n **OR** 0.05 + n	1
(b)(iv)	$\frac{2n}{(0.05 + n)}$	1
(b)(v)	N_2O_4 = 0.0375 NO_2 = 0.0250	1 1
(b)(vi)	$K_p = \frac{pNO_2^2}{pN_2O_4}$	1
(b)(vii)	$(0.4 \times 1.68 \times 10^5)^2 / (0.6 \times 1.68 \times 10^5)$ **OR** $0.4^2 \times 1.68 \times 10^5 / 0.6$ 44800 **OR** 44.8 Pa **OR** kPa	1 1 1
	Total:	13

30. 9701_s18_ms_21 Q: 1

(a)(i)	(It is a substance that) speeds up a reaction	**1**
	(by creating an alternative pathway / mechanism with) lower E_a	**1**
(a)(ii)	(a heterogeneous catalyst is in a) different state / phase (to the reactants)	**1**
(b)	−196 + 6S=O = (4 × 534) + 496	**1**
	S=O = 2828 / 6 = 471(.3)	**1**
(c)	**1 = B**	**1**
	2 = A	**1**
	3 = D	**1**
(d)(i)	Increases rate **AND** explanation re collisions	**1**
	By increasing number / proportion of / more molecules / particles / species with $E \geqslant E_a$	**1**
	(So) increases frequency of successful collisions / more successful collisions per unit time / higher chance of successful collisions per unit time / higher proportion of successful collisions per unit time	**1**
(d)(ii)	(Increasing T) decreases yield (of SO_3)	**1**
	(Forward) reaction is exothermic (or reverse argument)	**1**
	So increasing T shifts (equilibrium) reaction to left / towards reactants / in endothermic direction (to oppose the change in T)	**1**
(e)	$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$	**1**
(f)(i)		**1**
(f)(ii)	fully ionises/dissociates	**1**
	(Brønsted-Lowry acid is a) proton / H^+ donor	**1**
(f)(iii)	$H_2SO_4(l)/(aq) + H_2O(l) \rightarrow HSO_4^-(aq) + H_3O^+(aq)$	
	species and balancing	**1**
	correct state symbols on left hand side; all products aqueous	**1**

31. 9701_s18_ms_22 Q: 2

(a)	*option 1:* the mass of (all the atoms/ions in) a formula (unit) / molecule OR the (weighted) average / (weighted) mean mass of (all the atoms / ions in) the formula (unit) / molecule [1] relative / compared to 1 / 12 (the mass of an atom) of carbon–12 OR on a scale in which a carbon–12 (atom / isotope) has a (mass) of (exactly) 12 (units) [1] *option 2:* mass of one mol of a compound / formula (unit) / molecule [1] relative / compared to 1 / 12 (the mass) of 1 mol of C-12 OR in which one mol C-12 (atom / isotope) is (a mass of exactly) 12 g [1]	**2**
(b)(i)		
	4 shared pairs only (any symbols) (in NH_4)	**1**
	3 × dot-and-cross bonds AND 1 × 2 crosses (in NH_4)	**1**
(b)(ii)	tetrahedral	**1**
	109–109.5° (inclusive)	**1**
c(i)	*in any order explain meaning of:* *weak* partially ionises / incompletely dissociates (into ions) *Bronsted-Lowry acid* is a proton donor / H^+ (ion) donor / hydrogen ion donor	**2**
c(ii)	$NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq \text{ or } g) + H_3O^+(aq)$	
	all correct species and balancing	**1**
	correct state symbols	**1**
(d)(i)	$MnO_4^- + \mathbf{5}Fe^{2+} + \mathbf{8}H^+ \rightarrow Mn^{2+} + \mathbf{5}Fe^{3+} + \mathbf{4}H_2O$	**1**
(d)(ii)	(Fe^{2+} is a) reducing agent / reductant provides/donates electron(s) / loses electron(s) / increases its oxidation number / (Fe^{2+}) becomes Fe^{3+}	**2**
(d)(iii)	4×10^{-4} / 0.0004	**1**
(d)(iv)	2×10^{-3} / 0.002	**1**
(d)(v)	392	**1**
(d)(vi)	6	**1**