OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY A F325

Unit F325: Equilibria, Energetics and Elements

Specimen Mark Scheme

The maximum mark for this paper is **100**.

This paper consists of **8 p**rinted pages.

Question Number	Answer	Max Mark
1(a)(i)	O_3: Exp 2 has 4 times [H_2] as Exp 1 and rate increases by 4 ✓, so order = 1 with respect to O_3 ✓ C_2H_4: Exp 3 has 2 x [C_2H_4] and 2 x [O_3] as Exp 2; and rate has increased by 4 ✓, so order = 1 with respect to C_2H_4 ✓ rate = k [O_3] [C_2H_4] ✓	[5]
(ii)	use of k = rate / [O_3] [C_2H_4] = 1.0×10^{-12} / (0.5×10^{-7} x 1.0×10^{-8}) to obtain a calculated value ✓ $k = 2 \times 10^{3}$ ✓ units: $dm^3\ mol^{-1}\ s^{-1}$ ✓	[3]
(iii)	rate = 1.0×10^{-12} /4 = 2.5×10^{-13} ($mol\ dm^{-3}\ s^{-1}$) ✓	[1]
(iv)	rate increases and k increases ✓	[1]
(b)	$1\frac{1}{2}O_2(g) \longrightarrow O_3(g)$/ $O_2(g) + \frac{1}{2}O_2(g) \longrightarrow O_3(g)$ ✓ NO is a catalyst ✓ as it is (used up in step 1 and) regenerated in step 2/ not used up in the overall reaction✓ allow 1 mark for 'O/NO_2 with explanation of regeneration.'	[3]
2(a)(i)	H^+/proton donor ✓	[1]
(ii)	partially dissociates/ionises ✓	[1]
(b)	$C_6H_5OH(aq) + OH^-(aq) \rightleftharpoons C_6H_5O^-(aq) + H_2O(l)$ acid 1 base 2 base 1 acid 2 ✓	[1]

Question Number	Answer	Max Mark
(c)(i)	K_a = [$C_6H_5O^-$(aq)] [H^+(aq)] / [C_6H_5OH(aq)] ✓	[1]
(ii)	M_r C_6H_5OH = 94 ✓ [C_6H_5OH(aq)] 4.7/94 = 0.050 mol dm^{-3} ✓ 1.3 x 10^{-10} ≈ [H^+(aq)]^2 / 0.050 mol dm^{-3} ✓ ('=' sign is acceptable) [H^+] = √{ (1.3 x 10^{-10}) x (0.050) } = 2.55 x 10^{-6} mol dm^{-3} ✓ pH = –log[H^+] = −log 2.55 x 10^{-6} = 5.59 ✓ 3 marks: [H^+] ; pH expression ; calc of pH from [H^+]	[5]
(d)	[H^+(aq)] = 1.99 x 10^{-9} mol dm^{-3} ✓ [$C_6H_5O^-$(aq)] = K_a [C_6H_5OH(aq)] / [H^+(aq)]✓ [$C_6H_5O^-$(aq)] = 0.13 mol dm^{-3} ✓ *Calculation should use half the original concentration of phenol to find the concentration of sodium phenoxide in the buffer. This should then be doubled back up again.* *Do **not** penalise an approach that uses the original concentration of phenol in the expression above.*	[3]
(e)	Na/NaOH because some of the hexylresorcinol will react producing a mixture of the acid and the salt/conjugate base ✓ or mono/di salt of hexylresorcinol because the acid and its salt/conjugate base makes a buffer ✓	[1]
3(a)	rate of forward reaction = rate of reverse reaction ✓ concentrations of reactants and products are constant but they are constantly interchanging ✓	[2]
(b)(i)	K_c = [CH_3OH] / [CO] [H_2]^2 ✓	[1]
(ii)	use of K_c = [CH_3OH] / [CO] [H_2]^2 and moles to obtain a calculated value ✓ convert moles to concentration by ÷ 2: [CO] = 3.10 x 10^{-3} mol dm^{-3}; [H_2] = 2.60 x 10^{-5} mol dm^{-3}; [CH_3OH] = 2.40 x 10^{-2} mol dm^{-3} ✓ K_c = [2.60 x 10^{-5}] / [3.10 x 10^{-3}] [2.40 x 10^{-2}]^2 = 14.6 / 14.56 ✓ If moles not converted to concentration, calculated K_c value = 3.64 *(scores 1st and 3rd marks)* units: dm^6 mol^{-2} ✓	[4]

Question Number	Answer	Max Mark
(c)(i)	fewer moles of gas on right hand side ✓	[1]
(ii)	None ✓	[1]
(d)(i)	moved to left hand side/reactants increase/less products ✓	[1]
(ii)	ΔH negative because high temperature favours the endothermic direction ✓	[1]
(e)(i)	$CH_3OH + 1\frac{1}{2}O_2 \longrightarrow CO_2 + 2H_2O$✓	[1]
(ii)	adds oxygen/oxygenated ✓	[1]
4(a)(i)	Ca^+ is smaller than Ca/ proton : electron ratio in Ca^+ > Ca ✓ greater attraction from nucleus ✓	[2]
(ii)	"oxide" ion, O^- and electron are both negative ✓ hence energy is required to overcome repulsion ✓	[2]
(b)	completes Born-Haber cycle showing 1st IE↑ 2nd IE↑ 1st EA ↓ 2nd EA↑ and LE↓✓✓✓ (lose 1 mark for each error/omission) LE = –✓3451 kJ mol^{-1} ✓	[5]
(c)	differences in size of lattice enthalpies linked to ionic sizes/attraction using **more/less exothermic** rather than bigger or smaller. ✓ Mg^{2+} is smaller/Mg^{2+} has greater charge density✓ hence has stronger attraction for O^{2-}✓	[3]
(d)(i)	525 kJ mol^{-1} ✓	[1]
(ii)	193.6 J K^{-1} mol^{-1} ✓	[1]
(iii)	uses $\Delta G = \Delta H - T\Delta S$ ✓ To be feasible, $\Delta G = 0$ or $\Delta G < 0$ ✓ minimum $T = \Delta H / \Delta S$ ✓ Converts ΔS from J to kJ/÷1000 or converts ΔH from kJ to J ✓ 2712 K/ 2438 °C / 2439 °C ✓ *(units essential)*	[5]

Question Number	Answer	Max Mark
5(a)(i)	oxidation: $Fe \rightarrow Fe^{2+} + 2e^-$ ✓ reduction: $V^{3+} + e^- \rightarrow V^{2+}$ ✓	[2]
(ii)	E_{cell} = 0.18 V ✓	[1]
(b)(i)	system **III** x 2 and reversed + system **IV** ✓ $2H_2 + O_2 \rightarrow 2H_2O$/ $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$ ✓	[2]
(ii)	advantages: only H_2O formed/ non-polluting greater efficiency ✓ disadvantages: H_2 difficult to store ✓ H_2 difficult to manufactured initially / limited life cycle of H_2 adsorber/absorber ✓	[4]
6(a)	empirical formula N : O = 63.64/14 : 36.36/16 ✓ = 4.56 : 2.27 = 2 : 1. Empirical formula = N_2O ✓ molecular formula M_r of gas = 1.833 x 24 = 44 ✓ (calc 43.992) with these two pieces of evidence, assume that molecular formula = N_2O	[3]
(b)	any chemical that reacts to produce gas: e.g. carbonate and CO_2 ✓ accept: metal more reactive than Pb and H_2 balanced equation to match chemical added ✓	[2]
(c)	M_r(Lidocaine) = 236 ✓ moles Novocaine = 100 x 10^{-3}/236 = 4.24 x 10^{-4} ✓ concentration of Novocaine = 4.24 x 10^{-4} x (1000/5) = 0.0847/0.0848 mol dm^{-3} ✓	[3]

Question Number	Answer	Max Mark
(d)	mass C = 12 x 3.74/44.0 = 12 x 0.085 = 1.02 g ✓ mass H = 2/18 x 0.918 = 0.102 g ✓ mass O = 1.394 – (1.020 + 0.102) = 0.272 g ratio C : H : O = 1.02/12 : 0.102/1 : 0.272/16 ✓ = 0.0850 : 0.102 : 0.0170 / 5 : 6 : 1 / C_5H_6O ✓ $C_5H_{10}O$ has relative mass of 82 M_r is 164 = 2 x 82 ∴ molecular formula = $C_{10}H_{12}O_2$ ✓	[5]
7(a)(i)	transition element: has at least one ion with a partly filled d-orbital ✓ example showing electronic configuration with d orbital as between d^1 – d^9 ✓	[2]
	complex ion: a central metal ion surrounded by ligands with an example. ✓ ligand: molecule/ion with lone pair of electrons capable of forming co-ordinate/dative bonds to a metal ion ✓	[2]
(ii)	precipitation: equation ✓ colour of precipitate ✓	[2]
	ligand substitution: equation ✓ colour of substituted complex ✓	[2]
	redox: equation ✓ colour change ✓	[2]
	✎ The candidate clearly links observations to provide evidence for two reactions discussed. ✓	[1] [11]

Question Number	Answer	Max Mark
(b)	complex ions: octahedral example ✓ with 3-D diagram ✓	[2]
	tetrahedral example ✓ with 3-D diagram ✓	[2]
	square planar example (see also below) ✓ with 3-D diagram ✓	[2]
	stereoisomerism: *cis-trans* example, e.g. $Ni(NH_3)_2Cl_2$; platin with 3-D diagram ✓ optical example, e.g. $Ni(en)_3^{2+}$ ✓ with 3D diagrams ✓	[3]
	✎ The candidate clearly links features on the diagrams with a characteristic of the stereoisomerism involved ✓	[1] [Max: 9]
	Paper Total	**[100]**