Unit 4: General Principles of Chemistry I

Section A

Question Number	Question	
1 (a)	The hydrolysis of 1-bromobutane using hydroxide ions $C_4H_9Br(l) + OH^-(aq) \rightarrow C_4H_9OH(l) + Br^-(aq)$	
	Correct Answer	Mark
	D Titration with standard acid solution	**1**

Question Number	Question	
1 (b)	The decomposition of the benzenediazonium ion $C_6H_5N_2^+(aq) + H_2O(l) \rightarrow C_6H_5OH(aq) + N_2(g) + H^+(aq)$	
	Correct Answer	Mark
	A Collecting and measuring the volume of gas	**1**

Question Number	Question	
1 (c)	The reaction of acidified potassium manganate(VII) with propan-2-ol to give propanone and manganese(II) sulphate	
	Correct Answer	Mark
	B Colorimetry	**1**

Question Number	Question	
1 (d)	the catalytic decomposition of hydrogen peroxide	
	Correct Answer	Mark
	A Collecting and measuring the volume of gas	**1**

Question Number	Question	
2	1,2-dibromoethane reacts with potassium iodide dissolved in methanol according to the equation: $C_2H_4Br_2 + 2KI \rightarrow C_2H_4 + 2KBr + I_2$ The rate equation for this reaction is A rate = $k[KI]^2[C_2H_4Br_2]$ B rate = $k[KI]^2$ C rate = $k[C_2H_4Br_2]$ D not possible to deduce from this information	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
3	For the reaction between sodium bromate(V) and sodium bromide in acidic solution, the rate equation is: Rate = $k[BrO_3^-][Br^-][H^+]^2$ When the concentrations of all three reactants are doubled, the rate will increase by a factor of A 4 B 6 C 8 D 16	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
4 (a)	Calculate ΔS_{system}, in J mol^{-1} K^{-1}, for this reaction. A - 175.8 B + 175.8 C - 64.2 D + 64.2	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
4 (b)	Calculate $\Delta S_{surroundings}$, in J mol^{-1} K^{-1}, for this reaction at 298 K. A - 192 B + 192 C - 0.192 D + 0.192	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
5	For the equilibrium, $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ Which is the correct expression for K_p? A $\dfrac{[NH_3(g)]^2}{[N_2(g)][H_2(g)]^3}$ B $\dfrac{P_{N_2(g)} P_{H_2(g)}}{P_{NH_3(g)}}$ C $\dfrac{P^2_{NH_3(g)}}{P_{N_2(g)} P^3_{H_2(g)}}$ D $\dfrac{P_{N_2(g)} P^3_{H_2(g)}}{P^2_{NH_3(g)}}$	
	Correct Answer	Mark
	C $\dfrac{P^2_{NH_3(g)}}{P_{N_2(g)} P^3_{H_2(g)}}$	**1**

Question Number	Question	
6	The expression for K_c for the equilibrium $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ is $K_c = \frac{[SO_3(g)]^2}{[SO_2(g)]^2[O_2(g)]}$ What are the units of K_c in this equilibrium expression? A mol dm^{-3} B mol^2 dm^{-6} C dm^3 mol^{-1} D atm^{-1}	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
7	For the equilibrium $2NO_2(g) \rightleftharpoons N_2O_4(g)$ $\Delta H = -57.2$ kJ mol^{-1} which one of the following changes would result in a different value of the equilibrium constant? A an increase in temperature B a decrease in pressure C an increase in pressure D an increase in the concentration of $NO_2(g)$	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
8	Solutions of concentration 0.1 mol dm^{-3} of iron(II) ions and silver(I) ions were mixed at room temperature and allowed to reach equilibrium. $Fe^{2+}(aq) + Ag^+(aq) \rightleftharpoons Fe^{3+}(aq) + Ag(s)$ Which one of the following statements is true? A As the equilibrium position was approached, the forward reaction became slower until it stopped. B At the equilibrium position, no more Ag(s) reacted with Fe3+(aq). C At the equilibrium position, the rate of the forward reaction equalled the rate of the backward reaction. D No $Fe^{3+}(aq)$ reacted with Ag(s) until the equilibrium position was reached.	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
9 (a)	Have the lowest concentration of hydrogen ions	
	Correct Answer	Mark
	C $NH_3(aq)$ and $NH_4CL(aq)$	**1**

Question Number	Question	
9 (b)	Act as a buffer of pH about 5	
	Correct Answer	Mark
	D $CH_3COOH(aq)$ and $CH_3CO_2Na(aq)$	**1**

Question Number	Question	
9 (c)	Have a chloride ion concentration of 0.2 mol dm^{-3}	
	Correct Answer	Mark
	B HCl(aq) and NaCl(aq)	**1**

Question Number	Question	
10 (a)	What was the pH when 24.95 cm^3 of 1.00 mol dm^{-3} NaOH(aq) had been added to 25 cm^3 of 1.00 mol dm^{-3} HCl(aq). A 3 B 6 C 8 D 11	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
10 (b)	What was the pH when 25.05 cm^3 of 1.00 mol dm^{-3} NaOH(aq) had been added to 25 cm^3 of 1.00 mol dm^{-3} HCl(aq). A 3 B 6 C 8 D 11	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
10 (c)	Which one of the following indicators would be MOST suitable to use to determine the end point of this titration? pH range A methyl violet 0-1.6 B universal Indicator 3-11 C thymolphthalein 8.3-10.6 D alizarin yellow R 10.1-13.0	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
11	Which one of the following organic compounds does NOT exist? A an ester which is a structural isomer of a carboxylic acid $C_3H_6O_2$ B a carboxylic acid which is a structural isomer of an ester $C_2H_4O_2$ C an aldehyde which is a structural isomer of a ketone C_3H_6O D a ketone which is a structural isomer of an aldehyde C_2H_4O	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
12 (a)	A suitable starting material for this preparation would have the formula A $CH_3CH_2CH_2COH$ B $CH_3CH_2CH_2CH_2COOH$ C $CH_3CH_2CH_2COOH$ D $CH_3CH_2CH_2CH_2OOH$	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
12 (b)	Each stage in the sequence produced a 50% yield of required product. What is the minimum number of moles of the carboxylic acid which should be used in order to produce one mole of butanamide? A 0.25 B 2.00 C 2.50 D 4.00	
	Correct Answer	Mark
	D	**1**

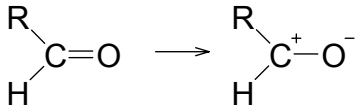
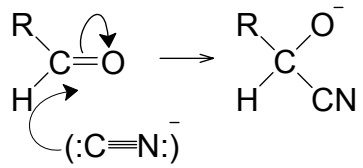
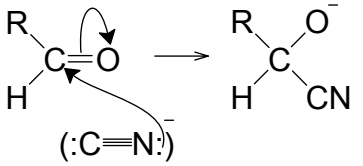
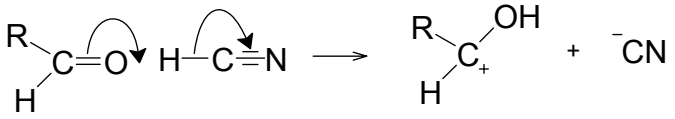
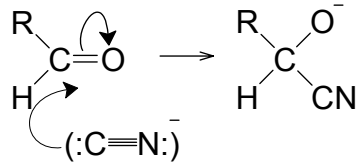
Question Number	Question	
12 (c)	Which of the following reagents is needed to convert the carboxylic acid into the acyl chloride? A chlorine B phosphorus(V) chloride C hydrogen chloride D ethanoyl chloride	
	Correct Answer	Mark
	B	**1**

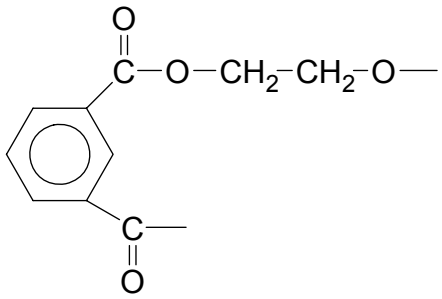
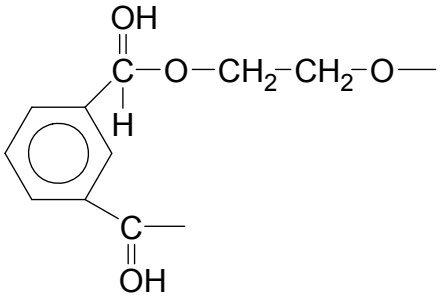
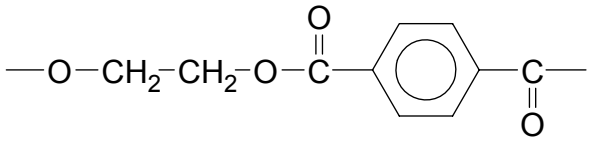
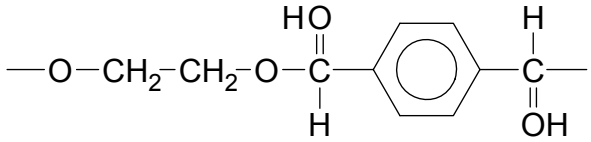
Question Number	Question	
13 (a)	Can be made by the oxidation of a primary alcohol.	
	Correct Answer	Mark
	A Butanoic acid, $CH_3CH_2CH_2COOH$	**1**

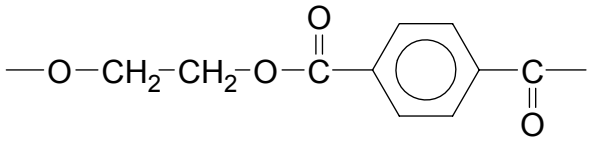
Question Number	Question	
13 (b)	Would be expected to react most rapidly with ethanol.	
	Correct Answer	Mark
	D Butanoyl chloride, $CH_3CH_2CH_2COCl$	**1**

Question Number	Question	
13 (c)	Would have 4 different chemical shifts in its nmr spectrum and an absorption at 2500 – 3300 cm^{-1} in its infrared spectrum. Use the data booklet as a source of information.	
	Correct Answer	Mark
	A Butanoic acid, $CH_3CH_2CH_2COOH$	**1**

Question Number	Question	
14 (a)	Which one of the following carbonyl compounds would produce a racemic mixture? A CH_3COCH_3 B C_2H_5CHO C HCHO D $C_2H_5COC_2H_5$	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
14 (b)	Which of the following best represents the first step of the mechanism for this reaction with an aldehyde? **A**  **B**  **C**  **D** 	
	Correct Answer	Mark
	B 	**1**

Question Number	Question
15 (a)	Which one of the following is a possible formula of the repeat unit of a polymer formed from ethane-1,2-diol and benzene-1,4-dicarboxylic acid. **A**  **B**  **C**  D 

	Correct Answer	Mark
	C 	**1**

Question Number	Question
15 (b)	What type of reaction is this? A dddition B condensation C dehydration D neutralisation

	Correct Answer	Mark
	B	**1**

Section B

Question Number	Question		
16 (a)	Give the name of this ester.		
	Acceptable Answers	Reject	Mark
	methyl butanoate Accept Methyl butaneoate	'an' missing	**1**

Question Number	Question		
16 (b)	Why does the ester have a comparatively low boiling point compared to the other three substances in the equation?		
	Acceptable Answers	Reject	Mark
	the other three substances can form **intermolecular** hydrogen bonds with themselves but the ester cannot.	Discussion of London Forces	**1**

Question Number	Question	
16 (c)	What is the name given to this type of reaction?	
	Correct Answer	Mark
	Hydrolysis	**1**

Question Number	Question		
16. (d) QWC (i-iii)	Suggest the reasons why manufacturers choose to use the chemically manufactured pineapple flavouring rather than the natural product and why consumers might prefer to choose the natural product.		
	Acceptable Answers	Reject	Mark
	Must cover advantages and disadvantages. Must **not** be contradictory **Advantages to manufacturers: (any two)** • not dependent on weather, seasons etc • consistent taste /concentration/more consistent • quality • or alternative ideas **Disadvantages to consumers : (any two)** • some people put off by 'non-natural' food • may not taste the same as natural product which may • contain other impurities • unable to describe the product as organic or alternative ideas	Cost with no justification	**4**

Question Number	Question		
16 (e)	Give the expression for the equilibrium constant, K_c, for this equilibrium and calculate its value. Explain why it has no units.		
	Acceptable Answers	Reject	Mark
	$K_c = \frac{[C_3H_7COOH(l)][CH_3OH(l)]}{[C_3H_7COOCH_3(l)][H_2O(l)]}$ (1) Accept eq subscripts **Moles at equilibrium** / **Concentration / mol dm^{-3}** **butanoic acid** = 4.4/88 = 0.05 / 1.67 **methanol** 0.05 / 1.67 **ester (methyl butanoate)** 0.05 / 1.67 **water** 0.95 / 31.7 all four equilibrium moles = (1) Conc at equilibrium = equilibrium moles ÷ 0.030 (1) $K_c = \frac{1.67 \times 1.67}{1.67 \times 31.7}$ (1) = 0.053 (1) ignore significant figures unless value given to 1 s.f. The units cancel because both the top and bottom of the fraction have units of concentration squared. Or same number of moles on both sides of the equation (1)	Absence of square brackets	**5**

Question Number	Question		
17 (a)	State the effect on the value of the equilibrium constant of an increase in temperature.		
	Acceptable Answers	Reject	Mark
	Value of equilibrium constant increases (1)		**1**

Question Number	Question		
17. (b) QWC (i) & (iii)	Use your answer to (i) to explain the effect of this change on the position of equilibrium.		
	Acceptable Answers	Reject	Mark
	If the equilibrium constant increases then more products will be formed (1) And the position of equilibrium will move to the right (1)		**2**

Question Number	Question		
18 (a)	Rewrite the equation omitting spectator ions.		
	Acceptable Answers	Reject	Mark
	$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$ Accept state symbols omitted		**1**

Question Number	Question		
18 (b) (i)	ΔS_{system}		
	Acceptable Answers	Reject	Mark
	Positive because a gas is given off (1) which is more disordered and so has more entropy (1)		**2**

Question Number	Question		
18 (b) (ii)	$\Delta S_{surroundings}$		
	Acceptable Answers	Reject	Mark
	Positive because the reaction is exothermic (1) and = - $\Delta H/T$ (1)		**2**

Question Number	Question		
18 (b) (iii)	ΔS_{total}		
	Acceptable Answers	Reject	Mark
	Positive because the reaction occurs / total entropy change is the sum of the two positive values above.		**1**

Question Number	Question		
18 (c) (i)	Suggest the reason for cleaning the magnesium ribbon with sand paper.		
	Acceptable Answers	Reject	Mark
	Surface coated with magnesium oxide (which would react to form water rather than hydrogen).		1

Question Number	Question		
18 (c) (ii) QWC (i-iii)	Calculate the number of moles of hydrochloric acid used up when all the magnesium reacts in one experiment and hence comment on whether the change in concentration during the reaction will have a significant effect on the validity of the assumption that the initial rate is proportional to 1/time. How would you overcome this potential error? [Take the relative atomic mass of magnesium as 24 in this and subsequent calculations]		
	Acceptable Answers	Reject	Mark
	Initial number of moles of HCl = 20 x 1 /1000 = 0.02 Number of moles of Mg = 0.1 / 24 = 0.00417 (1) number of moles of HCl which reacts is 0.00834 (1) Therefore number of moles of HCl left = 0.01166 (1) Ignore sig figs so the concentration nearly halves which would significantly reduce the rate and so make the assumption that the initial rate is proportional to 1/time invalid / inaccurate. (1) Increase the volume of acid to (at least) 50 cm^3 (1) Or measure the time to produce less than the full amount of gas Or use a smaller piece of magnesium. (1)		5

Question Number	Question		
18 (c) (iii)	Use the value of ΔH and other information given in the question to calculate the temperature change in an experiment assuming no energy is lost to the surroundings. Hence comment on whether this change in temperature will have a significant effect. How would you overcome this potential error? [ΔH = -467 kJ mol^{-1}. Assume that the specific heat capacity of the solution is 4.18 J K^{-1} g^{-1}]		
	Acceptable Answers	Reject	Mark
	Energy given out = 467 000 x 0.1/24 J = 1 946 J 20 x 4.18 x ΔT = 1 946 (1) $\Delta T = 23.3^{(o)}$ (1) Accept units of degrees celsius or kelvin This temperature change would significantly increase the rate of the reaction (1) Carry out the reaction in a water bath of constant temperature/use a larger volume of more dilute acid (1)		**4**

Question Number	Question		
18 (c) (iv)	The most difficult thing to measure accurately is the time it takes for the magnesium to disappear and the time measured can be up to 2 seconds out. Assuming this error, calculate the shortest time at 56 ^{0}C AND the longest time at 10 ^{0}C for this reaction. Complete the table for these times. Plot the two points on the grid below and join them with a straight line. From the gradient, which equals $-E_A/R$, of this line calculate another value for the activation energy.		
	Acceptable Answers	Reject	Mark
	At 329 time 4s 1/time = 0.25 s^{-1} ln(rate) = -1.39 (1) At 283 time 124s 1/time = 0.00806s^{-1} ln(rate) = -4.82 (1) [graph to be drawn] Plot line with new gradient = - 3.43 / 0.00049 = - 7 000 (1) Accept -6800 to -7200 Activation energy = + 7 000 x 8.31 = + 58.2 kJ mol^{-1} (1)		**4**

Question Number	Question		
18 (c) (v)	If the reaction mixture is not stirred, the magnesium tends to float on the surface of the acid. Suggest how this would affect the measurements of the rate of the reaction.		
	Acceptable Answers	Reject	Mark
QWC	Rate of reaction reduced because less surface area in contact with the acid. (1)		1

Question Number	Question		
18 (c) (vi)	Suggest TWO other improvements the student could do to this experiment to improve the accuracy or validity of the results.		
	Acceptable Answers	Reject	Mark
	Any two •Repeat the experiment at each of the temperatures •obtain an initial rate eg by measuring the volume of gas given off before the reaction is complete. •Other sensible suggestions.		2

Question Number	Question		
18 (c) (vii)	If ethanoic acid of the same concentration and at the same temperature is used instead of hydrochloric acid, explain how the rate would differ.		
	Acceptable Answers	Reject	Mark
	The rate should be lower, since ethanoic acid is a weaker acid (compared to hydrochloric acid) and so there will be a lower concentration of hydrogen ions present.		**1**

Question Number	Question		
19 **QWC** **(i-iii)**	One step in the production of nitric acid is the oxidation of ammonia. $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$ This is carried out at 900 °C over a platinum-rhodium catalyst and is an example of heterogeneous catalysis. Explain in terms of collision frequency and collision energy how the rate would change if the temperature were increased, and which of these causes the greater effect. What is the difference between a heterogeneous and a homogeneous catalyst? Suggest ONE advantage of using a heterogeneous catalyst in processes such as this.		
	Acceptable Answers	Reject	Mark
	Answer must be given in a logical order, addressing all the points using precise terminology • Collision **frequency** increases as particles moving more quickly (1) • More collisions have sufficient energy to overcome activation energy / more molecules on collision have energy ≥ activation energy (1) • A greater **proportion** of collisions result in reaction (1) • Collision energy has greater effect (1) • Homogeneous all in same phase and heterogeneous in different phases / gas and solid (1) • No need to separate products from catalyst (1)	More collisions More successful collisions	**6**

Question Number	Question		
20 (a) (i)	1 mole of P reacts with 1 mole of Br_2 molecules to form a compound with the formula $C_7H_{12}OBr_2$.		
	Acceptable Answers	Reject	Mark
	contains **one** carbon-carbon double bond Accept alkene		**1**

Question Number	Question		
20 (a) (ii)	When lithium tetrahydridoaluminate is reacted with P a compound with the formula $C_7H_{14}O$ is formed.		
	Acceptable Answers	Reject	Mark
	is a carbonyl compound / C=O group reduced (to CH(OH)) Accept aldehyde or ketone		**1**

Question Number	Question		
20 (a) (iii)	P forms an orange precipitate with 2,4-dinitrophenylhydrazine.		
	Acceptable Answers	Reject	Mark
	is a carbonyl compound Accept aldehyde or ketone		**1**

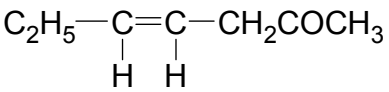
Question Number	Question		
20 (a) (iv)	When P is heated with Fehling's or Benedict's solution, the solution remains blue.		
	Acceptable Answers	Reject	Mark
	is a ketone / P is not an aldehyde	aldehyde	**1**

Question Number	Question		
20 (a) (v)	P is a Z-isomer.		
	Acceptable Answers	Reject	Mark
	has two groups on the same side of a C=C Accept cis isomer		**1**

Question Number	Question		
20 (b) (i) QWC (ii) & (iii)	The infrared spectrum of P has the following absorptions at wavenumbers above 1600 cm^{-1}. 3060 cm^{-1} 2920 cm^{-1} 1690 cm^{-1} 1660 cm^{-1}		
	Acceptable Answers	Reject	Mark
	3060 alkene (C-H stretching) 2920 alkane (C-H stretching) 1690 ketones (C=O stretching) 1660 alkene (C=C stretching) 4 Correct → 3 marks 3 Correct → 2 marks 2 Correct → 1 mark		**3**

Question Number	Question		
20 (b) (ii)	The nmr spectrum does NOT have a peak corresponding to a chemical shift, δ, of between 9 and 10.		
	Acceptable Answers	Reject	Mark
	not an aldehyde		**1**

Question Number	Question		
20 (b) (iii) QWC (ii) & (iii)	The mass spectrum showed the presence of peaks at mass/charge ratios of 15 and 29, but no peak at 43.		
	Acceptable Answers	Reject	Mark
	15 CH_3 group (1) 29 C_2H_5 group (1) 43 no C_3H_7 group (1)		**3**

Question Number	Question		
20 (c)	Given that P has a straight chain of carbon atoms in its formula, use the information you have deduced above to suggest a displayed formula for the pheromone P.		
	Acceptable Answers	Reject	Mark
	 ketone and Z (1) rest of molecule (1) Accept Fully displayed		**2**

Question Number	Question		
20 (d)	How could you use a purified sample of the orange precipitate in (a)(iii) to confirm the formula of P?		
	Acceptable Answers	Reject	Mark
	Measure its melting temperature (1) And compare with data book values (1)		**2**