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Answer ALL the questions. Write your answers in the spaces provided.

1. This question is about the reaction of iodine with propanone.



- (a) Suggest, **in outline**, THREE different methods for following the rate of this reaction. State which of the reactants or products could be measured by each method you choose.

Method 1

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Method 2

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Method 3

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(3)

- (b) The reaction is extremely slow at room temperature in the absence of H^+ ions as a catalyst.

Suggest how you would quench the reaction before carrying out a titration method to determine the concentration of iodine at different times.

Justify your answer.

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(2)



(v) Suggest an equation for the reaction between the species in the rate-determining step.

Explain why this step is likely to take place.

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(2)

(Total 13 marks)

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Q1

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N 3 1 0 2 7 A 0 5 1 6

2. One of the alarm pheromones for ants, compound **Q**, has the molecular formula $C_6H_{10}O$.

(a) State what can be deduced about compound **Q** from each of the following pieces of information.

(i) **Q**, $C_6H_{10}O$, is a non-cyclic organic compound. When saturated it would contain 14 hydrogen atoms.

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(1)

(ii) Compound **Q** does **not** react with sodium.

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(1)

(iii) One mole of compound **Q** reacts with one mole of bromine molecules, Br_2 , in the absence of sunlight.

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(1)

(iv) Compound **Q** gives a yellow precipitate with Brady's reagent, 2,4-dinitrophenylhydrazine.

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(1)

(v) When compound **Q** is warmed with Benedict's solution, a red precipitate is formed.

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(1)

(vi) Compound **Q** exists in the *trans* form.

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(1)



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(vii) Given that compound **Q** is a straight chain molecule with the two functional groups next to one another, give the displayed formula of **Q**.

(2)

(b) (i) Compound **Q**, $C_6H_{10}O$, can be converted into $C_6H_{14}O$ in two steps.

Give the reagent and any catalyst needed for each step.

Step 1

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Step 2

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(2)

(ii) Name the functional group which would now be present?

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(1)

(Total 11 marks)

Q2

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3. Phosphorus(V) chloride dissociates as follows:



Substance	Standard entropy, S^\ominus / $\text{J mol}^{-1} \text{K}^{-1}$
$\text{PCl}_5(\text{s})$	+ 166.5
$\text{PCl}_3(\text{l})$	+ 217.1
$\text{Cl}_2(\text{g})$	+ 165.0

(a) (i) Explain why the entropy of solid phosphorus(V) chloride, PCl_5 , is smaller than the entropy of liquid phosphorus(III) chloride, PCl_3 ?

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(1)

(ii) Calculate $\Delta S_{\text{system}}^\ominus$ for the forward reaction. Include a sign in your answer.

(1)

(iii) Is the sign of $\Delta S_{\text{system}}^\ominus$ as you would expect? Fully justify your answer.

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(2)

(b) Calculate $\Delta S_{\text{surroundings}}^\ominus$ for the forward reaction at 298 K. Include a sign and units in your answer.

(2)



- (c) (i) Use your answers to calculate $\Delta S_{\text{total}}^{\ominus}$ for the forward reaction at 298 K. Include a sign in your answer.

(1)

- (ii) Comment on the position of equilibrium at 298 K.

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(1)

- (d) In an experiment to investigate this equilibrium, 41.7 g of phosphorus(V) chloride (molar mass 208.5 g mol^{-1}) was heated in a closed vessel at $150 \text{ }^{\circ}\text{C}$ until equilibrium was established. The final pressure was found to be 4.32 atm and 0.15 moles of phosphorus(V) chloride remained. At this temperature all of the reactants and products are gaseous.

- (i) Give the expression for the equilibrium constant, K_p , and its units at this temperature.

(2)

- (ii) Complete the table

Substance	Moles at start	Moles at equilibrium	Partial pressure at equilibrium, p_{eq} /atm
$\text{PCl}_5(\text{g})$		0.15	
$\text{PCl}_3(\text{g})$	0		
$\text{Cl}_2(\text{g})$	0		
Total number of moles at equilibrium			

(3)



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(iii) Calculate K_p .

(1)

(iv) How would you expect the value of K_p to change, if at all, if the following changes were made? Justify each of your answers.

A Only 20.85 g of phosphorus(V) chloride had been used.

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B The temperature had been increased to 250 °C.

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(2)

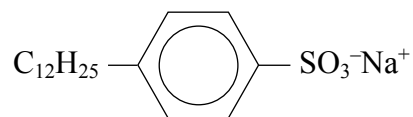
(Total 16 marks)

Q3

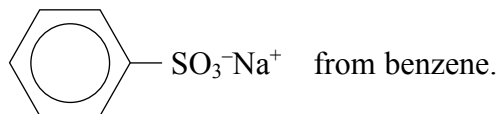
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4. An important industrial compound, S, has the formula



(a) (i) Name the reagents and give the conditions where necessary for the two steps needed to make



Step 1 Reagent

Conditions

Step 2 Reagent

(3)

(ii) Name the type of reaction in each step.

Step 1

Step 2

(2)

(b) (i) What is the specific name given to the reaction when an alkyl group is introduced into the benzene ring by electrophilic substitution?

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(1)

(ii) Give the molecular formula of the reagent and of the catalyst needed to make



Reagent

Catalyst

(2)

(c) Suggest an important use for compound S.

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(1)

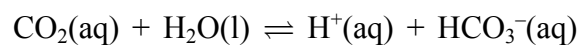
(Total 9 marks)

Q4



5. Human blood plasma is a buffer solution. It partly owes its buffer properties to carbon dioxide, produced by respiration, dissolving in the blood for transportation to the lungs.

Carbon dioxide dissolves in water establishing the equilibrium



(a) (i) Write the expression for K_a for this equilibrium and give its units.

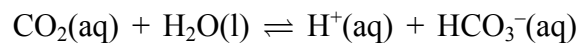
Units **(2)**

(ii) What is the relationship between $\text{p}K_a$ and K_a ? **(1)**

(b) Explain what is meant by a buffer solution.

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..... **(2)**

(c) $\text{HCO}_3^-(\text{aq})$ can act as an acid or a base.



In this equilibrium, decide whether $\text{HCO}_3^-(\text{aq})$ is acting as an acid or as a base. Give the reason for your decision.

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..... **(1)**



- (d) A sprinter had the pH and total carbonate concentration, $[\text{CO}_2 + \text{HCO}_3^-]$, of his blood plasma measured immediately before and after a race. The following results were obtained.

	pH	Total carbonate concentration, $[\text{CO}_2 + \text{HCO}_3^-]$ / mol dm^{-3}
Before race	7.4	2.52×10^{-2}
After race	7.3	1.98×10^{-2}

The pH of a buffer solution is given by the equation

$$\text{pH} = \text{p}K_{\text{a}} - \log \frac{[\text{acid}]}{[\text{base}]}$$

For this equilibrium $\text{p}K_{\text{a}}$ is 6.5.

- (i) Use this information, together with the data in the table, to calculate $\frac{[\text{acid}]}{[\text{base}]}$ before the race.

(2)

- (ii) The concentration of HCO_3^- is $0.0224 \text{ mol dm}^{-3}$. Calculate the concentration of CO_2 before the race.

(1)



THE PERIODIC TABLE

Group 0 7 6 5 4 3 2 1

Period	Key																	
1	Atomic Number Symbol Name Molar mass in g mol^{-1}																	
2	1 H Hydrogen 1											2 He Helium 4						
3	3 Li Lithium 7	4 Be Beryllium 9											10 Ne Neon 20					
4	11 Na Sodium 23	12 Mg Magnesium 24											17 Cl Chlorine 35.5	18 Ar Argon 40				
5	19 K Potassium 39	20 Ca Calcium 40	21 Sc Scandium 45	22 Ti Titanium 48	23 V Vanadium 51	24 Cr Chromium 52	25 Mn Manganese 55	26 Fe Iron 56	27 Co Cobalt 59	28 Ni Nickel 59	29 Cu Copper 63.5	30 Zn Zinc 65.4	31 Ga Gallium 70	32 Ge Germanium 73	33 As Arsenic 75	34 Se Selenium 79	35 Br Bromine 80	36 Kr Krypton 84
6	37 Rb Rubidium 85	38 Sr Strontium 88	39 Y Yttrium 89	40 Zr Zirconium 91	41 Nb Niobium 93	42 Mo Molybdenum 96	43 Tc Technetium (99)	44 Ru Ruthenium 101	45 Rh Rhodium 103	46 Pd Palladium 106	47 Ag Silver 108	48 Cd Cadmium 112	49 In Indium 115	50 Sn Tin 119	51 Sb Antimony 122	52 Te Tellurium 128	53 I Iodine 127	54 Xe Xenon 131
7	55 Cs Caesium 133	56 Ba Barium 137	57 La Lanthanum 139	72 Hf Hafnium 178	73 Ta Tantalum 181	74 W Tungsten 184	75 Re Rhenium 186	76 Os Osmium 190	77 Ir Iridium 192	78 Pt Platinum 195	79 Au Gold 197	80 Hg Mercury 201	81 Tl Thallium 204	82 Pb Lead 207	83 Bi Bismuth 209	84 Po Polonium (210)	85 At Astatine (210)	86 Rn Radon (222)
8	87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Unq Unnil- quadium (261)	105 Unp Unnil- pentium (262)	106 Unh Unnil- hexium (263)												
			▶ Lanthanide elements										67 Ho Holmium 165	68 Er Erbium 167	69 Tm Thulium 169	70 Yb Ytterbium 173	71 Lu Lutetium 175	
			▶▶ Actinide elements										89 Es Einsteinium (254)	90 Fm Fermium (253)	91 Md Mendelevium (256)	92 No Nobelium (254)	93 Lr Lawrencium (257)	

