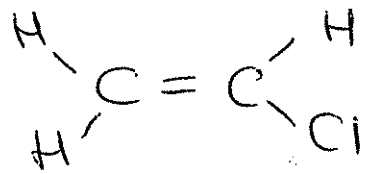
HAHS Half-Yearly Examination
2007
Chemistry
Exemplar Answers

1	A ●	B ○	C ○	D ○
2	A ○	B ○	C ○	D ●
3	A ○	B ●	C ○	D ○
4	A ○	B ●	C ○	D ○
5	A ○	B ○	C ○	D ●
6	A ○	B ●	C ○	D ○
7	A ○	B ●	C ○	D ○
8	A ○	B ●	C ○	D ○
9	A ○	B ○	C ○	D ●
10	A ●	B ○	C ○	D ○

11.

(a) Draw the structural formula for vinyl chloride. (1 mark)



✓ 1

(b) The uses of polymers are dependent on their properties.
Explain the uses of polyvinyl chloride in terms of its properties. (3 marks)

It is hard & brittle, but is not resistant to heat, 3
therefore heat resistant additives are mixed with it and
it is used in guttering and piping. Inflexible so good for
piping because of this property. Also used in credit
cards as it is hard and inflexible making the card
sturdy. It is due to the (Cl) that causes a chain stiffening
Softening additives are combined with it to make it so hard & inflexible.
used for soft furnishings ✓

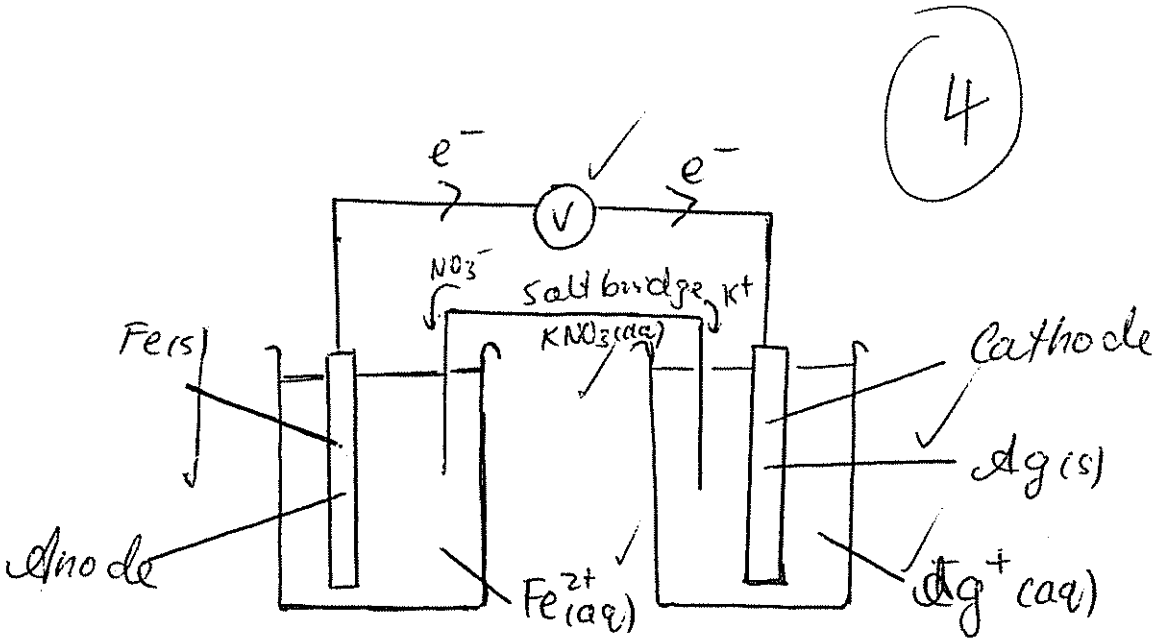
(b) The uses of polymers are dependent on their properties.
Explain the uses of polyvinyl chloride in terms of its properties. (3 marks)

Poly vinyle chloride has a chlorine side chain which makes it have a rigid structure ✓ it restricts its flexibility. It is used in drain pipes & tubing. It has a good thermal insulator so heat travels through it (slowly) It also as a high boiling point & melting point so it won't melt or dissolve under high temperatures. ✓ 3

12. A galvanic cell is represented by the following cell diagram (shorthand notation):

$$Fe / Fe^{2+} // Ag^{+} / Ag$$

(a) Draw a labelled scientific diagram for this cell showing the components above and also label the (i) anode
(ii) cathode
(iii) direction of electron flow on the diagram. (4 marks)



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(b) Write the oxidation and reduction half-equations for the galvanic cell and calculate the net E^0 for the above galvanic cell. (2 marks)

$Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-$ ✓ oxidation $E^\circ = 0.44\,V$

$Ag^+ + e^- \rightarrow Ag_{(s)}$ ✓ reduction $E^\circ = 0.80$ ✓

$E_{net} = E_{red} + E_{ox}$ ✓

$= 0.8\,V + 0.44\,V$ ✓

$= 1.24\,V$ 2

13. Evaluate the potential of biomass as a raw material for the production of fuel and chemicals for industry. (7 marks)

Biomass is any material containing a large percentage of cellulose. Cellulose is evident in most organic plants and thus is renewable. Cellulose can be broken down into monomer units of glucose, which then can be fermentated via yeast to Ethanol. Ethanol can act as an alternative fuel source and is already use in 10% - 20% concentrations in cars. Ethanol readily burns as shown $C_2H_5OH + 3O_2 \rightarrow 3H_2O_{(l)} + 2CO_{2(g)}$ and also burns cleaner than traditional fuel which is an advantage. Ethanol is also a renewable resource, thus it can be renewed via (CO_2, H_2O). However ethanol is also difficult to make as large agricultural land is needed thus causing land degradation, and waste from fermentation causes damage to the environment.

Ethanol can be denydrated to form ethene.

$C_2H_5OH_{(l)} \xrightarrow[\text{conc } H_2SO_4]{\text{catalyst}} C_2H_{4(g)} + H_2O_{(l)}$ in which ethene is important in the production of many polymers. Styrene made from ethene and benzene rings are used to form thin plastics and also used in styrofoam for insulation. PVC is also derived by reacting CH_2 with ethene, which then undergoes polymerisation. Therefore ethene is useful for production of ~~Electrical~~ materials.

In essence biomass is an useful raw material and it can be refined to produce ethanol and ethene, in which both are useful in the industry for many reasons

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$C_6H_{12}O_6 \xrightarrow[37°C]{\text{yeast}} 2C_2H_5OH + 2CO_2$

13. Evaluate the potential of biomass as a raw material for the production of fuel and chemicals for industry. (7 marks)

Biomass can be used in the production of an alternative fuel where cellulose can undergo hydrolysis to form glucose and can be fermented to produce ethanol which is a possible alternate fuel. It comes from a renewable resource as the plants that produce glucose can be grown any number of times. Ethanol also contains cleanly and completely reducing the toxic emmisions of CO and SO_2 which is safer for the environment. However, the process of hydrolysis is slow and the planting of biomass requires extensive space which leads to

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land clearing and other pollution problems. Fuel is what the plastics industry, and the conversion of biomass to ethanol can be achieved. The by the dehydration of ethanol ethene is produced which is a commercially significant monomer which can be used in making many polymers such as polyethylene and polypropene.

$C_2H_5OH_{(l)} \xrightarrow[H_2SO_4]{conc} C_2H_{4(g)} + H_2O_{(l)}$ ✓

However the production of fuel and use of biomass as energy is not economically viable at the moment because petroleum is currently ~~cheaper~~ cheaper, but as oil prices rise, biomass will become an ~~more~~ alternative as a raw material ✓

Biomass is plant material composed of cellulose and lignin. The cellulose can be converted to glucose by acid hydrolysis.

The glucose can then be converted to ethanol by fermentation with yeast.

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

Ethanol can be used as a fuel for a variety of purposes or ethanol can be dehydrated to ethene (ethylene)

$C_2H_5OH \rightarrow C_2H_4 + H_2O$

Ethylene can be used as a starting product to produce many polymers.
Biomass is a renewable resource and could be used as an alternative to non-renewable fossil fuels.
However there are currently some major problems in using large quantities of biomass as an alternative fuel and chemical source. This includes the fact that biomass fuels currently costs more to produce than fossil fuels, large amounts of arable land are needed to grow crops and this will reduce the land available to grow food and large amounts of smelly waste material is produced which is difficult to dispose. The use of biomass as an alternative fuel and chemical source is currently not economically viable.

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14. Compare the production of a named transuranic element and a named commercial radioisotope. (3 marks)

Transuranic Element - Neptunium (Np)
Neptunium is produced in a nuclear reactor by bombarding Uranium (92) with excess neutrons released in a nuclear reaction ($^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{236}_{92}U \rightarrow {}^{236}_{93}Np + {}^{0}_{-1}e$)
Commercial Radioisotope - Americium (Am)
Americium is also produced in a nuclear reactor by bombarding Plutonium (Pu) with excess neutrons, which cause Pu to decay into Am ($^{237}_{94}Pu + {}^{1}_{0}n \rightarrow {}^{238}_{94}Pu \rightarrow {}^{238}_{95}Am + {}^{0}_{-1}e$

14. Compare the production of a named transuranic element and a named commercial radioisotope. (3 marks)

A transuranic element such as Neptunium is produced in a nuclear reactor whereby neutrons are bombarded at a U-238 atom causing it to beta radiate and produce Np. A radioisotope such as technicium-99m is produced in a particle accelerator where a charged ion is accelerated ... nuclear reactor also. Technicium-99m used in medicine is produced in a particle accelerator where a neutron is accelerated and then bombarded with a Mo-98 atom causing it to become Mo-99. This atom then β radiates to produce technicium-99m which is meta stable. This then γ radiates and is used in hospitals for treatment.

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15. During your HSC course you performed a first-hand investigation to compare the reactivity of an alkene with that of its corresponding alkane. Describe the procedure followed and justify the appropriateness of the procedure used to obtain valid and reliable results. (6 marks)

In 5 test tubes, students placed 10 mL of cyclohexane into them. In another 5 test tubes students placed 10 mL of cyclohexene into them. One test tube from each of the 5 test tubes were used as a control. In all of the remaining 4 test tubes of different reactants, students placed 5 drops of freshly prepared bromine water down the side of the test tubes and observations were taken. Then and recorded. Students then shook the test tubes. Latterly and observed made observations in terms of colour change. (This was done in the absence of sunlight)

This procedure was very appropriate to obtain valid & reliable results. We used corresponding cycloalkanes & cycloalkenes to ensure that there was no error. * (bottom of page)

The use of bromine water was good as it indicated that a qualitative change in colour was observable by our results of the experiment. The bromine was decolourised by the solution containing the double bond which was synonymous with our results. As the controlled didn't change it proved that the bromine water caused the decolourisation of the cycloalkene. This experiment therefore results are valid.

The results were also reliable as the experiment was repeated 4 times (due to 4 test tubes used) to conduct same procedure) Therefore this procedure was appropriate in obtaining valid & reliable results.

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* this was done in the absence of sunlight as a substitution rxn would occur with the cycloalkane.

15. During your HSC course you performed a first-hand investigation to compare the reactivity of an alkene with that of its corresponding alkane. Describe the procedure followed and justify the appropriateness of the procedure used to obtain valid and reliable results. (6 marks)

Two test tubes were collected. With a clean pipette, 5 drops of cyclohexane was added to one test tube, and then 5 drops of cyclohexene was added to the other test tube in the same manner. Using a fresh pipette, 2 drops of bromine water was added to each test tube, and then the contents of each were carefully observed. Each test tube was then vigourously shaken for the same length of time, then observed again to test for and compare their reactivities, by paying particular attention to any colour changes.

The investigation was conducted from beginning to end in the absence of sunlight — this was achieved by shading all windows and closing the door. The investigation was carried out by several different teams/groups at the same time. This achieved reliability, since the investigation was repeated, and in the same environmental conditions also, i.e. temperature and pressure.

Validity was achieved by using the same equipment, by shaking each test tube for an equal length of time, and by using the appropriate corresponding alkane and alkene. Cyclohexane and cyclohexene share the same molecular structure, except for the double bond in cyclohexene. These 2 hydrocarbons were chosen for this reason, since the results can then be accounted for by the double bond, and nothing else, since the double bond is the only distinguishing feature between the 2 hydrocarbons.

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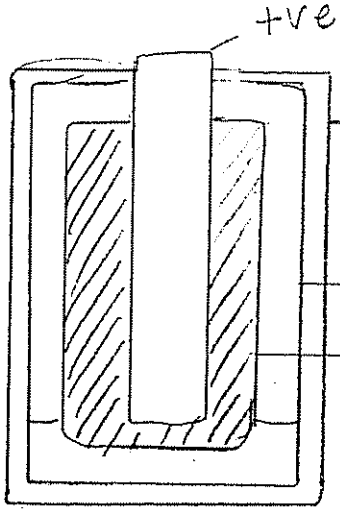
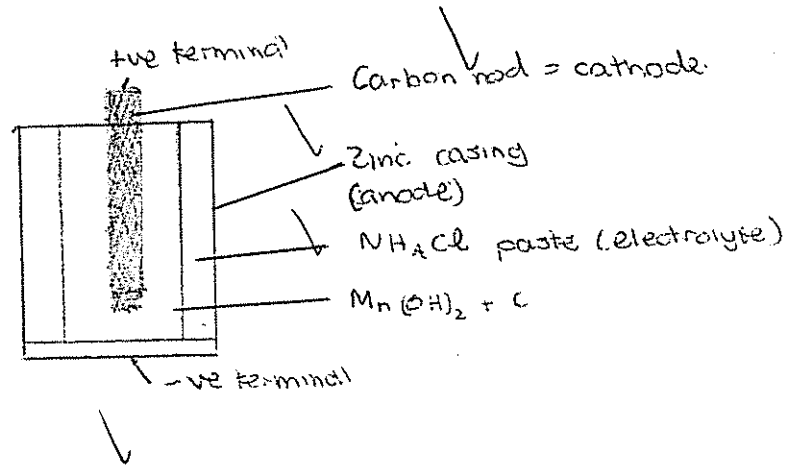
16. (a) Draw a scientific diagram of a dry cell OR a lead-acid cell
On your diagram identify the cathode, the anode and the electrolyte used. (2 marks)



Dry cell

2



2

(b) Write equations to represent the chemical reaction occurring at the anode and cathode of the cell you have drawn in (a). (2 marks)

Anode: $Zn_{(s)} \longrightarrow Zn^{2+} + 2e^-$

Cathode: $2MnO_2 + 2H^+ + 2e^- \longrightarrow Mn_2O_{3(s)} + H_2O_{(l)}$

2

(b) Write equations to represent the chemical reaction occurring at the anode and cathode of the cell you have drawn in (a). (2 marks)

Anode: $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$

Cathode: $2MnO_{2\,(aq)} + 2NH_4^+{}_{(aq)} + 2e^- \rightarrow Mn_2O_{3\,(aq)} + 2NH_{3\,(aq)} + H_2O_{(l)}$

2

(c) Evaluate the dry cell OR the lead-acid cell in comparison to ONE of the following:

- button cell (e.g. silver cell)
- fuel cell
- vanadium redox cell
- lithium cell
- liquid junction photovoltaic device

in terms of environmental impact. (3 marks)

The dry cell and the lithium cell have relatively no environmental impact. The only concern is the disposal of the batteries. Lithium cells are rechargeable and last for quite some time (evident - since it is used in pacemakers). Dry cell batteries have short half lives due to the electrolyte paste attacking the zinc anode casing. However, during disposal both batteries are inert (don't react with anything). Both batteries could be said to be environmentally friendly. (3)

The dry cell does not contain any dangerous chemicals to the environment. However if the NH_4^+ reacts too quickly the cell could burst, and since the Zn is oxdised it can corrode and cause the battery to leak, but this causes little damage if disposed of correctly Silver button cells on the other hand do contain heavy metals which need to be disposed of correctly to reduce environmental damage. The KOH within the cell is caustic and so must also be disposed of efficently The silver can be recycled and so less strain is placed on new silver mines for battery use if they are recycled. Therefore dry cells are more environmentally friendly as they have less potential to damage the environment than silver button cells

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The lead-acid cell contrasts greatly from the lithium cell in terms of environmental impact. The lead-acid cell has highly toxic components such as the Lead, which are highly detrimental to organisms, and therefore the environment. It can also seep into the water table, which also would have a great impact on the environment

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A lithium cell differs greatly from the lead-acid cell in terms of environmental impact. They have minimal impact on the environment as the major components Lithium and Iodine, are not greatly detrimental to organisms. Lithium cells also don't leak dangerous fluids so this also reduces the environmental impact of Lithium cells compared to a lead acid cell.

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The Dry cell batteries and Lithium cells both does not impact the environment much. The disposal of dry cells batteries where weak acid or reaction product leaks out from the cells are non-toxic and pose little problems on the dumps. Meanwhile, Lithium batteries are rechargeable and hardly any lithium batteries are disposed, meaning less harmed are done to the environment. If the Lithium battery is disposed, the substances inside the battery would hardly leak due to its good shell life. Therefore both batteries cause little or no harm for the environment.

17. (a) Assuming that all the mass loss was due to the release of carbon dioxide, graph the mass of carbon dioxide released against the time that has elapsed. (4 marks)

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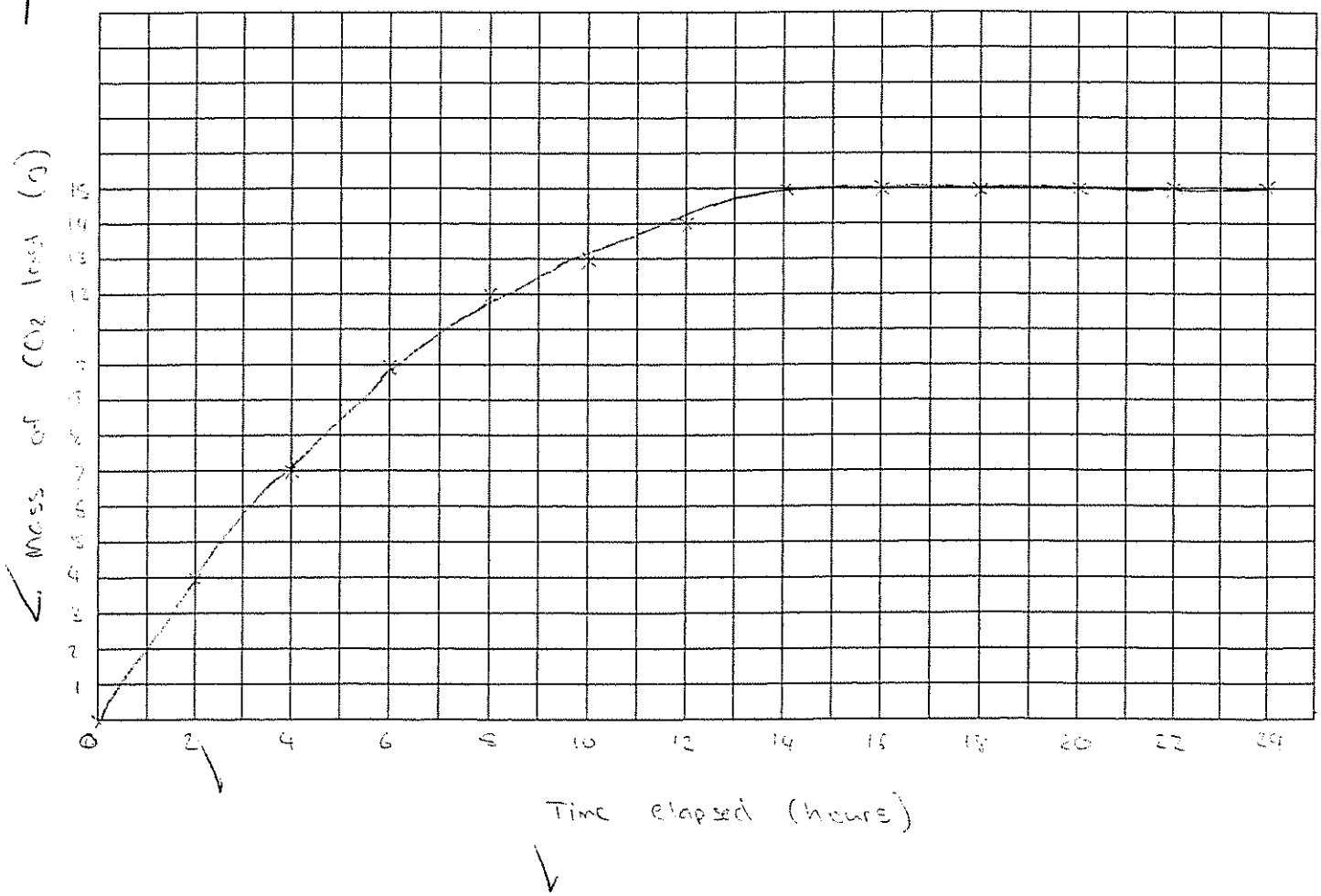
Mass of CO_2 lost over time



(b) Calculate the total volume of carbon dioxide released at 25°C and 100 kPa. Show full working. (2 marks)

$m_{(CO_2(g))} = 15\ g$

$V_M = 24.79\ L$

$n_{CO_2} = \frac{m}{M} = \frac{15}{12.01 + 2(16.00)} = 0.3408...\ mol$

2 $n = \frac{V}{V_M}$

$\therefore V_{(O_2} = n \cdot V_M = 0.3408... \times 24.79 \div 8.45\ L$ (3 sig. fig) of CO_2 gas released

(c) The volume of the liquid in the can is measured before and after its degassing and it is found to have NOT changed appreciably.

Using your knowledge of the kinetic theory of matter, propose an explanation to account for this observation. (2 marks)

2 The carbon dioxide gas was trapped in between the "gaps" between the liquid molecules. It is for this reason, that the volume of the liquid will not change appreciably as the gas merely took up empty space rather than creating more space - i.e. more volume.

(c) The volume of the liquid in the can is measured before and after its degassing and it is found to have NOT changed appreciably.

Using your knowledge of the kinetic theory of matter, propose an explanation to account for this observation. (2 marks)

~~The volume of liquid~~ The H_2CO_3 molecules in the can were occupying the spaces between the molecules of water in the can. Also, it is attached to a molecule of water so act as one molecule with a negligible difference in volume from simple H_2O molecules.

18. Outline the relationship between the position of elements in the Periodic Table and the acid-base behaviour of their oxides. (2 marks)

From the left, the elements are basic and at the right the elements are acidic. The acidic of the oxides of the element increases from left to right. Basicity ~~increases~~ of the oxides of the element increases from top to bottom and acidity of the oxides of the elements decreases from top to bottom. Group VIII are no oxides and N & C are neutral oxides.

2

Non-metal oxides are generally acidic (where non-metals are mainly found on the right of the periodic) metal oxides are generally basic (where metals are mainly found towards the left end of the periodic table). Therefore acidity of oxides increases when moving from left to right across the periodic table.

2

19. (a) Predict the colour a solution of phenol red would be if a few drops were added to a 1 mol/L solution of hydrochloric acid. (1 mark)

yellow

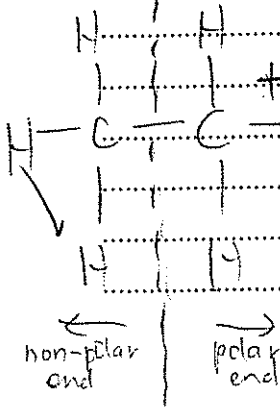
(b) Explain your prediction in part (a) with reference to Le Chatelier's principle. (3 marks)

3 Le Chatelier's principle states that if a system at equilibrium is disturbed, a shift in equilibrium will occur to minimise the disturbance. In this case, as HCl(aq) is added, there is an increase in $[H^+]$. This increase is a disturbance and so the reverse reaction (as written) is favoured to reduce $[H^+]$ thereby increasing concentration of yellow $C_9H_{14}O_5S$ and reducing the concentration of $C_9H_{13}O_5S^-$, which is red.

(b) Explain your prediction in part (a) with reference to Le Chatelier's principle. (3 marks)

3 Le Chatelier's principle states that if system at equilibrium is disposed by a charges and thus disturbing the equilibrium, the equilibrium will shift in such a way as to counteract and minimise the effect of the disturbance. Therefore by adding a few drops of 1 mol/L solution of hydrochloric acid to the solution of phenol red it is increasing the concentration of hydrogen (as $\xrightarrow{}$ HCl → acidic and thus contains a large amount of hydrogen ions) and thus causing the equilibrium ~~to~~ ie shift away from the increase ie: ~~more~~ shift to the left and hence become more yellow as to use up the excess hydrogen ions present in ~~the equili~~ system.

3 Ethanol's structure allows it to dissolve both polar & non-polar substances. Its non-polar end is able to dissolve non-polar substance by forming dispersion forces with the solute (in where ethanol is the solvent). Ethanol's polar end is able to form dipole-dipole & ion-dipole interactions with polar substances & ionic substance and the (OH) on the polar end is able to form H-bonds with the OH's of other compounds — thus these various forces of attraction occurring between ethanol and the solutes allows it to dissolve polar substances eg. water



20. Ethanol is used as a solvent for both polar and non-polar substances. Account for this property of ethanol.
(3 marks)

☆ Ethanol is the second most important solvent commercially and industrially as it an ethanol molecule contains a polar hydroxyl end and a non-polar alky end. The polar hydroxyl end allows dipole-dipole interactions, dipole-ion interactions and hydrogen bonding between ionic and polar substances, allowing them to dissolve. The non-polar alkyl end allows weak dispersion forces to occur, hence dissolving other non-polar substances. Therefore since the ethanol molecule is a relatively small molecule it is neither excessively polar or non-polar allowing both substances to dissolve. It is used in perfumes and food colourings. A diagram would enhance your answer.

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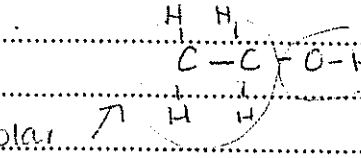
20. Ethanol is used as a solvent for both polar and non-polar substances. Account for this property of ethanol.
(3 marks)

Ethanol is used as a solvent for both non polar and polar substances because it has both non-polar and polar in its structure.



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Because of this the polar end can force dipole-dipole and hydrogen bonds with other polar substances (like dissolves like)
With the non-polar end, it can force dispersion forces with other non-polar substances
∴ ethanol can dissolve both polar and non polar substances.

Ethanol is able to dissolve both polar and non-polar substances due to its structure (see below)
The polar hydroxyl group is able to form hydrogen bonds and ion dipole dipole interactions with other polar substances and dissolve poles substances. It is also able to dissolve ionic substances by forming ion-dipole interactions
The non polar hydrocarbon chain is able to dissolve non-polar substances by forming dispersion forces

3