VCE Chemistry

Model Answers to Questions in the Sample Paper for the Accredited VCE Chemistry Course 2013 to 2016.

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Answers to multiple-choice questions

1 C	2 B	3 B	4 B	5 A	6 A
7 D	8 D	9 B	10 A	11 C	12 A
13 A	14 C	15 A	16 B	17 D	18 D
19 B	20 D	21 B	22 B	23 D	24 C
25 A	26 D	27 D	28 C	29 C	30 B

Answers to Part B
Question 1

a. carbohydrate, polysaccharide
b. $C_6H_{12}O_6$
c. Plants such as sugar cane and corn are able to regrow in a relatively short time. They can be used produce the ethanol at a rate similar to the rate of consumption of the ethanol. Hence, ethanol produced in this way is said to renewable. Fossil fuels are produced naturally over many millions of years and are considered to non-renewable as they are used up at faster rate than they can be replenished. There are limited reserves of fossil fuels while renewable energy fuels provide limitless energy. The production of renewable fuels derived from biomass includes bioethanol, biodiesel, biomethane. The production and use of fuels from renewable resources produces a smaller carbon footprint than production and use of fuels from fossil fuel reserves. Growing plants as a source of biofuels uses land, water and fertilizers that could be used to grow food crops. The large scale clearing of natural vegetation to grow crops to be converted to biofuels has had a negative environmental

impact, causing land degradation and destroying habitat. In one application, bioethanol can be used to replace petrol in cars. However, as it has a lower energy content compared to petrol, more will be needed to produce the same energy output.

d. $\Delta H = 1364 \text{ kJmol}^{-1}$

   Energy released in the calorimeter by combustion of ethanol $= 12.5 \times 13.75 = 171.88 \text{ kJ}$
   n(ethanol) $= 171.88/1364 = 0.1260$ mol.
   mass ethanol combusted in the calorimeter$= 0.1260 \times 46.0 = 5.80$g (3 sig. figs.)

e. The same mass of liquid would contain less ethanol. The total heat energy release when the ethanol is combusted will therefore be less. Hence the calculated amount of ethanol would be less.
   OR
   There will be a lower change in temperature due to heat being absorbed by the water. This leads to a smaller calculated energy value and hence a smaller mass of calculated ethanol present.

Question 2.
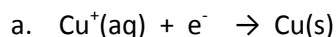
a. $Cu^{+}(aq) + e^{-} \rightarrow Cu(s)$
b. $Q = It = 0.900 \times 315 \times 60 = 17010.0$ coulomb
   $n(e^{-}) = 17010.0 /96500 = 0.17627$ mol.
   $n(Cu) = n(e^{-}) = 0.17627$ mol
   mass Cu $= 0.17627 \times 63.5 = 11.19 = 11.2$ g (3 sig. figs.)

c. i. 400.0mgL^{-1}
   ii. $[Cu^{2+}]$ in 25.0 mL of the stock solution $= [Cu^{2+}]$ in 500.0mL volumetric flask
                           $= 100.0/25.0 \times 400 = 1600 \text{ mgL}^{-1}$
      mass Cu^{2+} in 500mL solution $= 500.0/1000.0 \times 1600 = 800.0$mg $= 0.800$ g
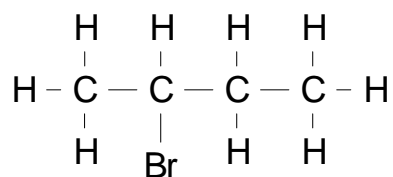   original mass of Cu plate $=0.855$ g
      percentage purity $= 0.800 / 0.855 \times 100 = 93.6\%$ (3 sig. figs.)

Question 3

a. but-2-ene   (As stereo isomerism is not part of the current VCE course, the inclusion of (cis) or (E) in the name is not required)
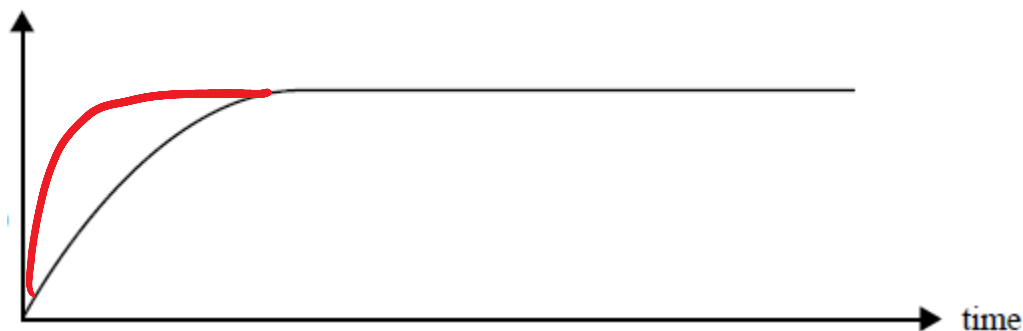
b. i. As the structure of 2,3-dibromobutane is symmetrical it contains only two carbon environments and the ^{13}C NMR spectrum will show two peaks rather than four as shown in the provided spectrum.   2-bromobutane has four carbon environments and its ^{13}C NMR spectrum will show 4 signals.

ii.

H - C - C - C - C - H

(structure: four carbons in a chain; top substituents H H H H; bottom substituents H, Br, H, H)

iii. hydrogen bromide.

c.   i.

time

ii. The reaction pathway of a catalysed reaction has lower activation energy than the reaction pathway of an uncatalysed reaction. Hence the rate in the catalysed reaction is faster.

Question 4

a.   There are three sets of peaks in the proton NMR hence three hydrogen environments.
b.   The septuplet indicates that there are six equivalent protons on adjacent carbon atoms i.e there must two adjacent methyl,CH_3, groups .
c.   The broad absorption at 3000 cm^{-1} is generated by the O-H bonds in acids . The narrow absorption at the tip of the broader absorption is caused by overlap between C-H and O-H signals
The absorption at 1700 cm^{-1} is generated by the C=O bonds.

d.

(structure: H - C - C - C with top H H and double bond O, and a branch H - C - H, and O, H)
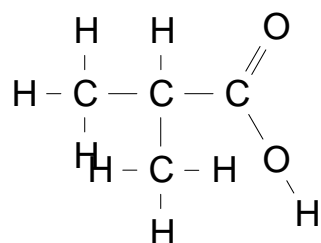
e. The radio waves used in NMR spectroscopy change the spin state of nucleons. Odd number nucleons are required in the nucleus for it be NMR active as is the case of ^{13}C. The molecular formula indicates the presence of four carbon atoms and the ^{13}C NMR indicate three equivalent carbon environments. Hence it can be deduced that that two of the carbon atoms are equivalent. Additional information that can be obtained from the proton NMR but not the ^{13}C NMR include

- splitting pattern which provides information regarding the number of equivalent protons attached to neighbouring carbon atoms and
- peak areas which identifies the ration ratio of hydrogen atoms in different environments.
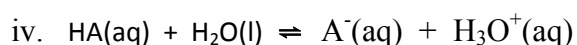
f. i. 14.4mL

ii. $NaOH(aq) + HA(aq) \rightleftharpoons NaA(aq) + H_2O(l)$
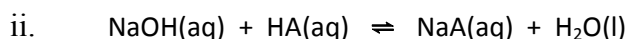
  $n(HA) = n (NaOH) = 14.4/1000 \times 0.100 = 1.44 \times 10^{-3}$mol.

  Conc. (HA) $= 1.44 \times 10^{-3} \times 1000/20.0 = 0.0720$M

iii. pH before any base is added $= 3.0$ and $[H_3O^+] = 10^{-3}$M

iv. $HA(aq) + H_2O(l) \rightleftharpoons A^-(aq) + H_3O^+(aq)$

  $K_a = [A^-][H_3O^+] / [HA]$

At equilibrium $[A^-] = [H_3O^+] = 10^{-3}$M

Since HA is a weak assume it will not react to any great extent and that the [HA] = 0.0720M

Ka $= 10^{-3} \times 10^{-3}/0.0720 = 1.4 \times 10^{-5}$ M (2 sig figs)

Question 5

a.
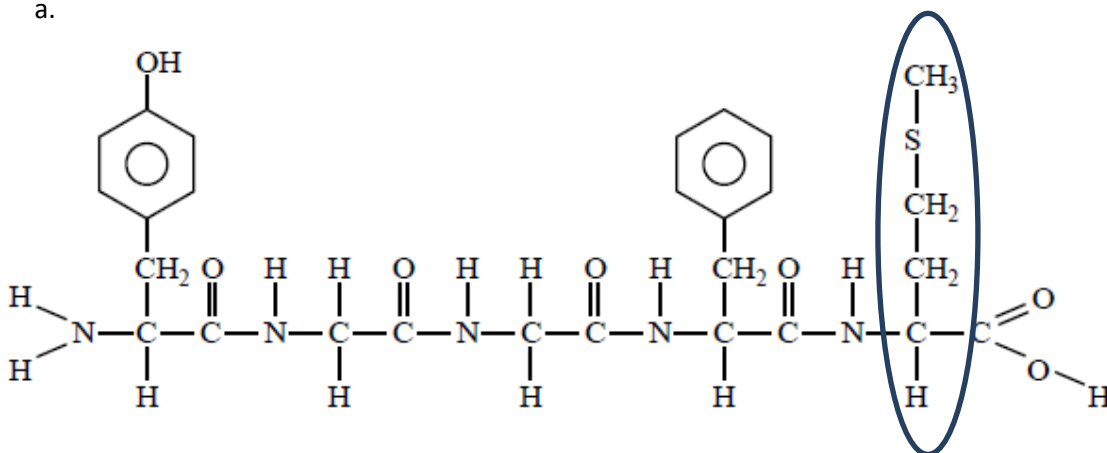
b.   Distance the solvent from has moved = 28.9 -2.8 = 26.1 cm

Distance methionine spot has moved = 17.5 – 2.8 = 14.7 cm

Rf = 14.7/26.1 = 0.563

If solvent front reached 20.0 cm mark only it has moved a distance of 20.0 -2.8 = 17.4 cm

The methionine spot will have moved   0.563 x 17.4 = 9.80 cm.

The spot will have reached the 9.80 + 2.8 = 12.6 cm mark on the scale.

c.   The mobile phase containing the components of the mixture is drawn up the stationary phase. The components undergo a continual process of adsorption onto the stationary phase and desorption into the mobile phase. The rate of adsorption and desorption of each component in the mixture depends upon how strongly it adsorbs onto the stationary phase and readily it dissolve back into the mobile phase. As each component in the mixture undergoes the adsorption/desorption process to different degree the components separate. The components which bond less strongly with the solid phase and are more soluble in the mobile phase move further up the chromatography column or plate. (Adapted from Heinemann Chemistry Two Enhanced Edition page 62)

d.

$$\begin{array}{c} COOH \\ | \\ H_3N^+{-}C{-}H \\ | \\ H \end{array}$$
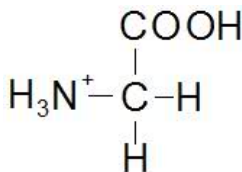
Question 6.

a.   K = $[CH_3OCH_3][H_2O] /[CH_3OH]^2$

b.   For the reverse reaction K = 1/5.74 = 0.174

c. i. $[CH_3OH]$ = 0.340/20.0 = 0.0170M

ii. At equilibrium $[CH_3OCH_3] = [H_2O]$

K = 5.74 = $x^2/(0.0170)^2$

x^2 = 5.74 x $(0.0170)^2$= 0.0016589

$CH_3OCH_3]$ = √0.0016589= 0.0407M

Amount CH_3OCH_3 = 0.0407 x 20.0 = 0.815 mol. (3 sig figs)

iii. n(CH_3OH) reacted = 2 n(CH_3OCH_3) produced

= 2 X 0.815 = 1.630 mol

initial n(CH_3OH) = n(CH_3OH) consumed + n(CH_3OH) in equilibrium mixture.

= 1.630 + 0.340 = 1.970 mol.

Question 7

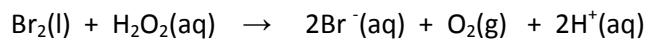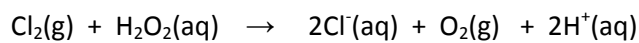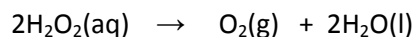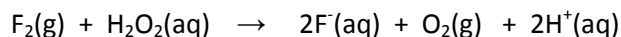a. A balanced equation for any reaction with an oxidant that has a standard redox potential greater than 0.68 volt is acceptable. That is the oxidant had to be higher on the electrochemical series than:

$O_2(g)$ + $2H^+(aq)$ + $2e^-$ → $H_2O_2(aq)$
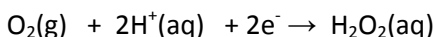
One of the following equations is required

$F_2(g)$ + $H_2O_2(aq)$ → $2F^-(aq)$ + $O_2(g)$ + $2H^+(aq)$

$2H_2O_2(aq)$ → $O_2(g)$ + $2H_2O(l)$

$2Au^+(aq)$ + $H_2O_2(aq)$ → $2Au(s)$ + $O_2(g)$ + $2H^+(aq)$

$Cl_2(g)$ + $H_2O_2(aq)$ → $2Cl^-(aq)$ + $O_2(g)$ + $2H^+(aq)$

$Br_2(l)$ + $H_2O_2(aq)$ → $2Br^-(aq)$ + $O_2(g)$ + $2H^+(aq)$

$2Ag^+(aq)$ + $H_2O_2(aq)$ → $2Ag(s)$ + $O_2(g)$ + $2H^+(aq)$

$2Fe^{3+}(aq)$ + $H_2O_2(aq)$ → $2Fe^{2+}(aq)$ + $O_2(g)$ + $2H^+(aq)$
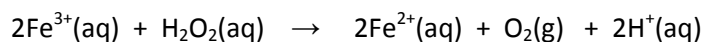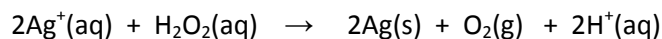
b. The rate of the reaction cannot be predicted by electrode potentials. If the rate of the reaction is slow no reaction would have been observed in the first 5 minutes. OR

A reaction can only be predicted from the electrochemical series if it place under standard conditions. ie at a concentration of 1.0M, a temperature of 25^0C and a pressure of 1 atmosphere. A reaction may not occur as predicted if the conditions are nonstandard.

Question 8

a. A secondary cell can be recharged, a primary cell cannot be recharged.

In a primary cell the products of the discharge move away from the electrodes.

b. Lithium is one of the strongest reductants and will produce a high voltage when combined with a suitable oxidant.
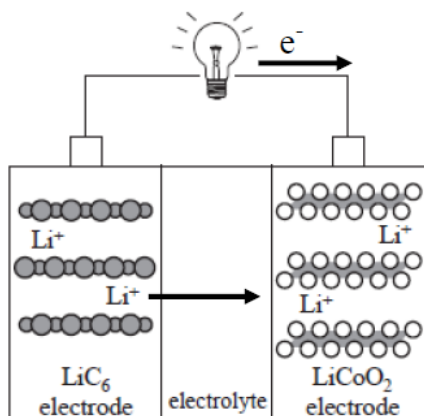
OR Lithium is a light weight metal (low relative atomic mass) and its use in electrochemical cells greatly reduces cells' mass and increases the power to mass ratio.

c $n(H_2) = \frac{1}{2} n(Li) = \frac{1}{2} \times 1.00/6.9 = 0.07246$ mol

    pressure $p = 950/760 \times 101.3 = 126.6$ kPa   temperature $T = 273 + 20.0 = 293$ K

    $V = nRT/V = 0.07246 \times 8.31 \times 298 / 126.6 = 1.42$ L   (2 or 3 sig figs)

d.

Question 9

a. Increase in $CO_2 = 0.58 - 0.42 = 0.16$ % by mass

                    $= 0.16/100 \times 5.15 \times 10^{18} = 0.00824 \times 10^{18} = 8.2 \times 10^{15}$ kg. (2 sig. figs.)

b. Energy produced from half CO_2 increase.

Half mass $CO_2 = \frac{1}{2} \times 8.24 \times 10^{15} \times 10^3 = 4.21 \times 10^{18}$ g

$n_{(CO2)} = 4.21 \times 10^{18} /44.0 = 9.36 \times 10^{16}$ mol

Energy produced $= 9.36 \times 10^{16} \times 394 = 3.7 \times 10^{19}$ kJ (2 sig.figs.)

c   An increase in concentration of atmospheric CO_2 increases the concentration of aqueous or dissolved CO_2. This forces the position of equilibrium of the second reaction to the right, increasing the concentration hydrogen ions in solution thus lowering the pH.
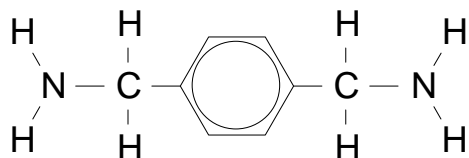
Question 10

a. NaOH or KOH or OH^-

b.
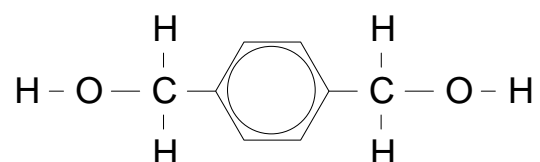
c. $Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$

d.

e. amide

Question 11

mass $MgNH_4PO_4.6H_2O$ = 4.14g

$n(P) = n(MgNH_4PO_4.6H_2O) = 4.14/245.3 = 0.01688$mol

$n(P_2O_5) = \frac{1}{2} n(P) = \frac{1}{2} \times 0.01688 = 0.008439$ mol

m $(P_2O_5) = 0.008439 \times 142.0 = 1.198$g

% mass$(P_2O_5) = 1.198/3.256 \times 100 = 36.81\%$ (4 sig figs)

Question 12

Dissolve known amounts of X in a known volume of water and immediately measure absorbances of X before it reacts extensively with water. Plot a calibration graph of absorbency against concentration and deduce equation using simple mathematical procedure or equation of best fit functions in spreadsheet software.
OR
Measure the absorbances of standard solutions of X that have been prepared using a solvent other than water and that does not absorb at the same wavelength as X. Plot a calibration graph and deduce equation.

b. i   absorbance at equilibrium (when graph flattens out) = 0.250

           absorbance = 4.15[X]   [X] = 0.24/4.14 = 0.0602 M (3 sig figs)

ii.   [X] = 0.110M   absorbance = 4.15 x 0.110 = 0.457

iii   n(X) converted = 0.110 – 0.0602 = 0.0498 mol

   % converted = 0.0498/0.110 x 100 = 45.3% (3 sig. figs.)

Question 13

 A valid conclusion cannot be made as variables other than concentration were not kept constant.

Factors that determine the rate of a reaction are concentration, temperature and surface area. The student varied all these factors in his experiment. In addition, in flask one, HCl was the limiting reagent which meant that the reaction would stop before all the calcium carbonate had been consumed. Calcium carbonate was the limiting reagent in flask 2.

A better design would be to use equal masses of calcium carbonate lumps in both flasks, assuming that equal masses of lumpy calcium carbonate have equivalent surface areas. Carry out the experiments at the same temperature. Add the same volume of acid to both flasks but varying the concentration of the acids. The volume of acid should be sufficient to ensure complete reaction at the lower concentration. The design can be further enhanced by repeating the experiment using more than two acid concentrations.