FACTFILE:
GCE CHEMISTRY

ANSWERS TO A22 FACTFILE QUESTIONS

ANSWERS

5.1 Mass spectrometry

1.(i) 29 [1]

(ii) 31: CH_3O^+ [1]
57: $CH_3CH_2CO^+$ [1]

(iii) the presence of a ^{13}C atom [1]

2. D [1]
P has m/z of 32; Q has m/z of 8; R has m/z of 16; left to right from lowest to highest m/z

3.(i) base peak is the tallest peak in the spectrum [1]

(ii) m/z value of 55 [1]

(iii) 45: $COOH^+$ [1]
100: $OOCCH_2CH_2CO^+/(CH_2CO)_2O^+$ [1]

4. D [1]
Peaks at m/z values of 35, 37, 70, 72 and 74 caused by the following: $^{35}Cl^+$, $^{37}Cl^+$, $(^{35}Cl—^{35}Cl)^+$, $(^{35}Cl—^{37}Cl)^+$ and $(^{37}Cl—^{37}Cl)^+$

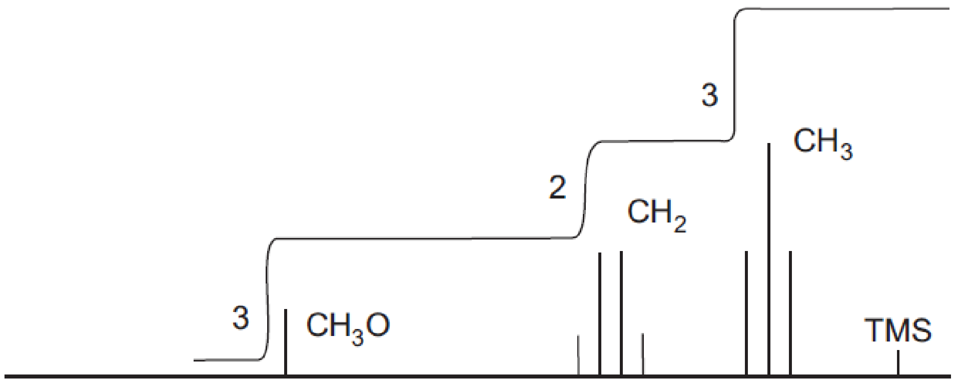
5. C [1]
Base peak is the tallest peak

5.2 NMR Spectroscopy

1.(a)
(i) tetramethylsilane [1]

(ii) all the hydrogen atoms are equivalent [1]
the signal is outside the usual range [1]
TMS is inert/unreactive [1] max [2]

(b)



splitting of peaks [1]
each set of peaks [3] – correct heights, shift and label
integration curve above [1] [5]

2.(a) CH_3COO^+ [1]

(b)(i) ratio 2:3:3 or 3:2:3 [1]
CH_3:CH_2:CH_3/no of Hs in each environment [1] [2]

(ii) high chemical shift value quartet near electronegative O
lowest chemical shift value CH_3 from CH_2CH_3
intermediate chemical shift value singlet proximity to COO
all three [2]
errors [-1] [2]

(iii) (quartet) due to split by three chemically equivalent H (n+1) [1]

(iv) no H atoms bonded to adjacent atoms (to split signal) [1]

3. C [1]
three environments so C or D; singlet not as deshielded as quartet so cannot be D as singlet would be COOH H atom and it would be most deshielded

4.(i) it only produces one signal (for the methyl groups) [1]
which is out of the region for most proton spectra [1] [2]

(ii) the proton is next to a methylene/CH_2 group [1]

(iii) the proton is next to a methyl/CH_3 group [1]

(iv) the protons are next to nitrogen which is deshielding/withdraws electrons [1]

(v) an extra peak [1]
which would be below the quartet [1]

the integration would show 3:2:1:3 [1]
some/all the peaks would change their chemical shift [1]
to a maximum of [3] [3]

5.3 Volumetric analysis

1. C [1]
moles of $Na_2S_2O_3$ = $\frac{36.4\times0.10}{1000}$ = 3.64 × 10^{-3} mol
1 mol of H_2O_2 : 2 mol $Na_2S_2O_3$
moles of H_2O_2 in 25.0 cm^3 = $\frac{3.64\times10^{-3}}{2}$ = 1.82 × 10^{-3} mol
concentration of diluted H_2O_2 = 1.82 × 10^{-3} × 40 = 0.0728 mol dm^{-3}
dilution factor = 20 (25 diluted to 500)
concentration of original solution = 0.0728 × 20 = 1.456 mol dm^{-3}

2. A [1]
moles of $Na_2S_2O_3$ = $\frac{30.0\times0.05}{1000}$ = 1.5 × 10^{-3} mol
1 mol KIO_3 : 6 mol $Na_2S_2O_3$
moles of KIO_3 in 25.0 cm^3 = $\frac{1.5\times10^{-3}}{6}$ = 2.5 × 10^{-4} mol
concentration of KIO_3 = 2.5 ×10^{-4} × 40 = 0.01 mol dm^{-3}

3.(i) $5FeC_2O_4 + 3MnO_4^- + 24H^+ \rightarrow 3Mn^{2+} + 5Fe^{3+} + 10CO_2$

(ii) moles of MnO_4^- = $\frac{18.2\times0.002}{1000}$ = 3.64 x 10^{-5} mol [1]
5 mol FeC_2O_3 : 3 mol MnO_4^-

moles of FeC_2O_4 in 20.0 cm^3 = $\frac{3.64\times10^{-5}}{3}$ × 5= 6.067 × 10^{-5} mol [1]
moles of FeC_2O_4 in 100 cm^3 = 6.067 × 10^{-5} × 5 = 3.033 × 10^{-5} [1]
mass of Fe in mg = 3.033 × 10^{-5} × 56 × 1000 = 16.99 or 17 mg [1]

4.(i) 0.0018 mol [1]

(ii) 0.0018 mol [1]

(iii) 0.018 mol [1]

(iv) 0.2 mol [1]

(v) 0.2 – 0.018 = 0.182 mol [1]

(vi) 0.091 mol [1]

(vii) 9.1 g [1]

(viii) 91 % [1]

5.(i) $Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 6Fe^{3+}$ [1]

(ii) moles of $Cr_2O_7^{2-}$ = $\frac{23.5\times0.01}{1000}$ = 2.35 × 10^{-4} mol
moles of Fe^{2+} in 25 cm^3 = 2.35 × 10^{-4} × 6 = 1.41 × 10^{-3} mol
moles of Fe^{2+} in 250 cm^3 = 0.0141 mol
mass of $FeSO_4$ in 250 cm^3 = 0.0141 × 152 = 2.143 g
mass of $FeSO_4$ in one tablet = $\frac{2.143}{5}$ = 0.429 g [1]
[-1] for each error; [-1] if no mass unit [4]

6. moles of NaOH = $\frac{18.6 \times 0.1}{1000}$ = 1.86×10^{-3} mol
moles of HCl remaining in 25 cm^3 = 1.86×10^{-3} mol
moles of HCl remaining in 250 cm^3 = 0.0186 mol
moles of HCl added initially = $\frac{20.0 \times 2}{1000}$ = 0.04 mol
moles of HCl which reacted with $CaCO_3$ = 0.04 – 0.0186 = 0.0214 mol
moles of $CaCO_3$ = $\frac{0.0214}{2}$ = 0.0107 mol
mass of $CaCO_3$ = 0.0107 × 100 = 1.07 g
percentage of $CaCO_3$ = $\frac{1.07}{1.12}$ × 100 = 95.5 %
[-1] each error [4]

5.4 Chromatography

1.(i) $R_f = \frac{\text{distance moved by spot}}{\text{distance moved by solvent}}$ [1]

(ii) more soluble in the stationary phase [1]
than the mobile phase/solvent [1] [2]

2.(i) ester is more volatile [1]
passes through the column faster [1] [2]

(ii) one peak with 90% of the area within it [1]
other peak(s) with 10%/rest of the area [1] [2]

3. A [1]

4. W [1]

5.5 Transition metals

1.(a) An element which forms (at least one stable) ion with a partially filled d-subshell/An element which has an atom with a partially filled d-subshell [1]

(b)(i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3$ [1]

(ii)

ion	oxidation number	colour
	+2	violet
$VO_2^+(aq)$	+5	
	+4	blue
	+3	green

(error [-1]) [4]

2.(i) polydentate/chelate/hexadentate [1]

(ii) $[Cr(H_2O)_6]^{3+}$ + $edta^{4-}$ → $[Cr(edta)]^-$ + $6H_2O$ [1]

(iii) more molecules/species on the right hand side [1]
increases the entropy/disorder [1] [2]

3. $Cu^{2+}(aq)$ blue
$Cr^{3+}(aq)$ green
$Co^{2+}(aq)$ pink
$Fe^{3+}(aq)$ yellow/orange error [-1] [3]

4. D [1]

5.(i) two co-ordinate bonds [1]
formed by two lone pairs [1] [2]

(ii) $[Ni(H_2O)_6]^{2+}$ + 3en → $[Ni(en)_3]^{2+}$ + $6H_2O$ [2]

(iii) entropy increases [1]
4 particles to 7 particles [1] [2]

5.6 Electrode potentials

1. B [1]
most easily oxidised so most powerful reducing agent

2.(a) From negative electrode to positive electrode [1]
VO^{2+} half cell is negative electrode/MnO_4^- half cell is positive electrode [1] [2]

(b) vanadium oxidised from +4 to +5 and manganese reduced from +7 to +2 [1]
redox is when the oxidation number of one elements goes up and the oxidation number of another one goes down in the same reaction [1] [2]

(c) $VO^{2+} + H_2O \rightarrow VO_2^+ + 2H^+ + e^-$ [1]
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ [1]
$MnO_4^- + 5VO^{2+} + H_2O \rightarrow Mn^{2+} + 5VO_2^+ + 2H^+$ [1] [3]

(d)(i) blue to yellow [2]

(ii) pink/purple to colourless [2]

(e) + 1.51 – (+1.02) = 0.49 V [2]

(f) completes the circuit (no metal present) [1]
ions in the salt conduct the electricity [1] [2]

(g) hydrogen gas (bubbled) over a
platinum electrode (covered in platinum black) [2]
25 °C, 1.0 mol dm^{-3} $[H^+]$, pressure 100 kPa [2] [4]

3.(i) hydrogen electrode: $H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$ [1]
oxygen electrode: $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$ [1] [2]

(ii) $2H_2 + O_2 \rightarrow 2H_2O$ [1]

(iii) +1.23 V [1]

(iv) fuel cells require a constant supply of fuel [1]

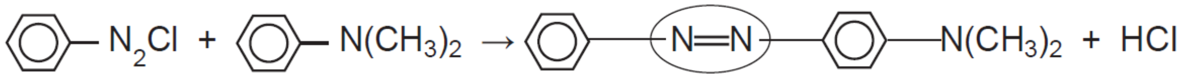
5.7 Amines

1. B [1]

2.(a) Step A: tin and concentrated hydrochloric acid [1]
Step B: NaOH/KOH solution [1] [2]

(b) (dilute) hydrochloric acid and sodium nitrite [1]
below 10 °C [1] [2]

(c)



equation [2]
azo group [1] [3]

3.(i) 1,4-diaminobutane or butane-1,4-diamine [1]

(ii) amino group(s) can form hydrogen bonds with water [1]

4. pentacene has an extensively delocalised electron system [1]
the energy levels are close together [1]
less energy is needed to raise the electrons to a higher level [1]
energy is thus in the visible region [1]
colours other than red are absorbed (by pentacene) [1]
to a maximum of [4] [4]

5.8 Amides

1. A [1]

2.(i) $CH_3COOH + NH_3 \rightarrow CH_3COONH_4$ [1]

(ii) $CH_3COONH_4 \rightarrow CH_3CONH_2 + H_2O$ [1]

(iii) hydrochloric acid: CH_3COOH [1]
sodium hydroxide solution: CH_3COONa [1]

(b)(i) A: P_4O_{10} [1]
B: $LiAlH_4$ [1] [2]

(ii) $RNH_2 + CH_3COCl \rightarrow CH_3CONHR + HCl$ [1]

(iii) determine melting point/description of apparatus [1]
heat slowly [1]
record temperature when melting starts and stops/range [1]
compare to tables [1] [4]

5.9 Amino acids

1. C [1]

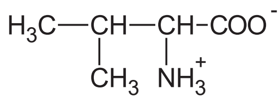
2. primary: sequence of amino acids in the chain [1]
   secondary: the twisting/coiling of the chain to form a α-helix/β-pleated sheet by intramolecular hydrogen bonds [1]
   tertiary: the bending/folding of the secondary structure to give a 3D shape held together by hydrogen bonding/disulfide bridges/ionic interactions [1]
   [3]

3.(i) enzymes have an active site [1]
provides a path of lower activation energy [1] [2]

(ii) intramolecular forces are disrupted/broken [1]
the enzymes will be denatured/structure disrupted by higher temperatures/the active site will no longer be effective [1] [2]

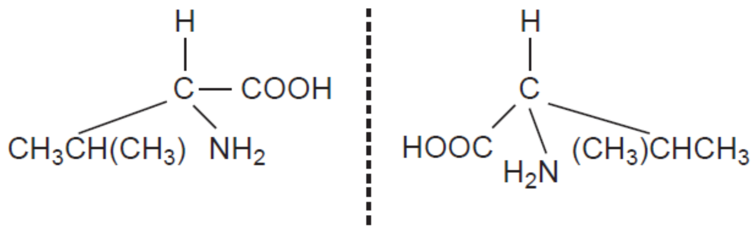
4.(i) molecule or ion which has a permanent positive and negative charge but which is neutral overall/ion which has permanent $-NH_3^+$ and $-CO_2^-$ and is neutral overall
[2]

(ii)



[1]

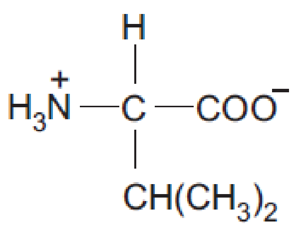
(iii)



([-1] for each mistake [2]

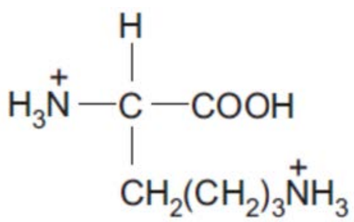
5. B [1]

6.(i)



[1]

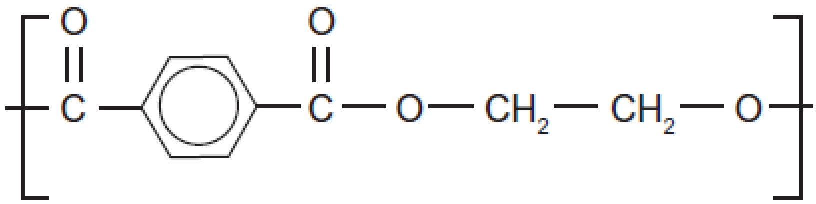
(ii)



[1]

5.10 Polymer chemistry

1.(i)



[1]

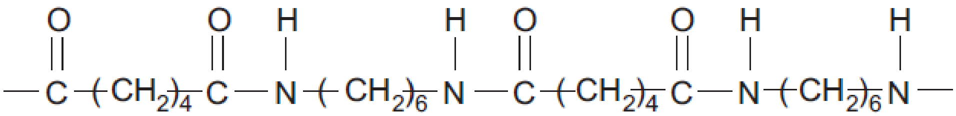
(ii) water bottles/take away containers/sauce bottles [1]

2.(i) $HOOC(CH_2)_4COOH + H_2N(CH_2)_6NH_2 \rightarrow —OC(CH_2)_4CONH(CH_2)_6NH— + H_2O$ [3]

(ii) any two from: ropes/brushes/clothes [2]

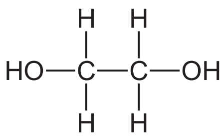
(iii) nylon is a polyamide/amide [1]
can he hydrolysed (to form original molecules) [1]
polythene cannot be hydrolysed [1]
hence it ends up in landfill or incineration [1] [4]

3.(a)



(each error [-1]) [3]

(b)(i)

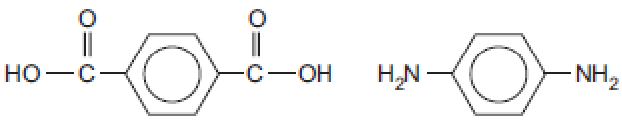


[1]

(ii) ethane-1,2-diol [1]

(c)(i) 2 [1]

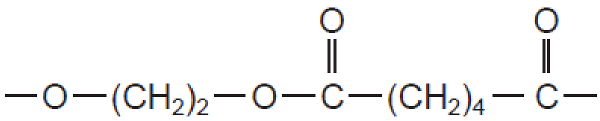
(ii)



[2]

4.(a)
(i) condensation [1]

(ii)



([-1] for each mistake) [2]

(b)(i) —N=C=O [1]

(ii) amide group can be hydrolysed [1]

5.11 Chemistry in medicine

1. sequesters Ca^{2+} ions [1]
prevents blood clotting [1] [2]

2.(i) ester is more volatile [1]
passes through the column faster [1] [2]

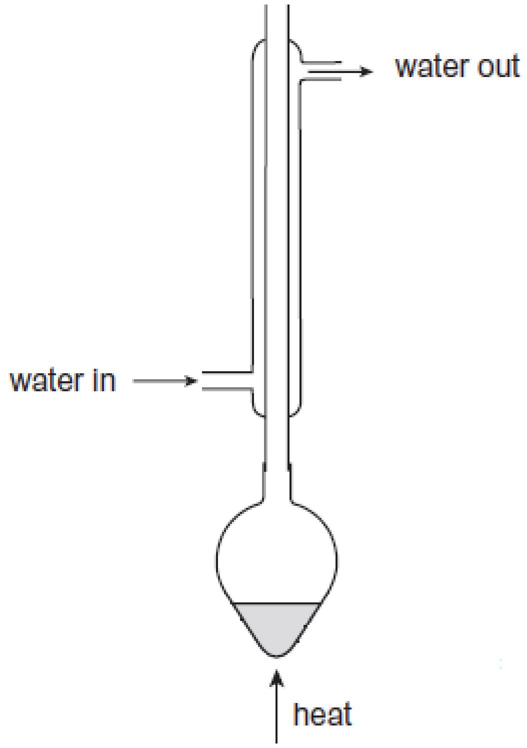
(ii) one peak with 90% of the area within it [1]
other peak(s) with 10%/rest of the area [1] [2]

3.(a)
(i) catalyst [1]

(ii) slowly [1] with stirring/cooling [1] [2]

(b)(i) repeated boiling and condensing of a (reaction) mixture [1]

(ii) no gaps around flask
water in at the bottom and out at the top
open at the top
heating contents of flask
(any errors [-1]) [4]



(c) $(CH_3CO)_2O + H_2O \rightarrow 2CH_3COOH$ [1]

(d) crystallise the aspirin [1]

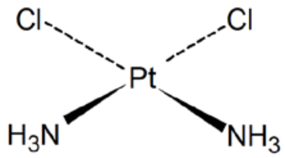
(e) faster/drier product [1]

(f) minimum volume of hot water [1]
filtered while hot [1]

cooled (to crystallise) [1] [3]

(g) theoretical yield of aspirin = $\frac{5.0}{0.65}$ = 7.692 g
moles of aspirin = $\frac{7.692}{180}$ = 0.04273 mol
moles of 2-hydroxybenzoic acid = 0.04273 mol
mass of 2-hydroxybenzoic acid = 0.04273 × 138 = 5.897 g
([-1] each error) [4]

4.



[1]

binds to (guanine in) DNA and prevents cell replication [1]
cell enters programmed cell death [1] [3]