Question 1

1.1	D
1.2	D
1.3	C
1.4	C
1.5	D
1.6	C
1.7	B
1.8	B
1.9	B
1.10	D

Question 2

2.1.1 Ne✓ (1)

2.1.2 N_2✓ (1)

2.1.3 diamond✓ (1)

2.1.4 NH_3✓ (1)

2.1.5 NaCl✓ (1)

2.1.6 NH_3✓ (1)

2.1.7 N_2 or diamond✓ (1)

2.2.1 Water or H_2O✓ (1)

2.2.2 Ion✓-dipole✓ force (2)

2.2.3 $Mg(NO_3)_2(s) \rightarrow Mg^{2+}$✓ (aq) + 2✓$NO_3^{-1}$ ✓ (aq) ; phase indicators✓ (4)

2.2.4 n = c.V

= 0,15 x 0,2 ✓(conversion)

= 0,03✓(✓) mol of $Mg(NO_3)_2$

n = 2 x 0,03 = 0,06✓ mol of NO_3^- (coe from 2.2.3) (3)

2.2.5 n = c.V

= 0,5 x 0,2

= 0,1 mol of NO_3^- ions in total

n = (0,1 -0,06) = 0,04 mol of NO_3^- ions added from sodium nitrate.

(coe from Q2.2.4)

M = n x M

= 0,04 x 85

= 3,4 g of $NaNO_3$ (5)

Marks the following skills:

✓✓ Method to work of total mols of NO_3^- including conversion
✓ Subtraction to get NO_3^- ions added from sodium nitrate
✓ Molar mass 85
✓ Mass of $NaNO_3$

OR

$[NO_3^-]$ = 2 x 0,15 = 0,3 $mol.dm^{-3}$ from magnesium nitrate

Added $[NO_3^-]$ = 0,5 -0,3 = 0,2 $mol.dm^{-3}$

Since $NaNO_3$ is 1:1

Therefore $[NaNO_3]$ = 0,2 $mol.dm^{-3}$

n = cV
= 0,2 x 0,2
= 0,04 mol

And m = nM
= 0,04 x 85
= 3,4g

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Question 3

3.1.1 Heat of reaction is the net✓ change of chemical potential energy✓ of the system. (2)

3.1.2 The activated complex is a temporary transition state✓ between the reactants and the products. ✓ (2)

3.2 The colliding particles must have **enough kinetic energy greater than or equal to the activation energy.** ✓✓
The colliding particles must have the **correct orientation.** ✓✓ (4)

3.3.1 $Zn + 2HCl \rightarrow ZnCl_2 + H_2$ (3)
reactants✓ products✓bal✓

3.3.2 Use powdered or granulated zinc✓✓ (increase surface area 1 mark only)
Use concentrated hydrochloric acid✓✓ (increase [ ] 1 mark only)
Heat the test-tube of reactants✓✓ (6)

3.3.3 It interacts with the reactants in such a way that the reaction follows an **alternative path**✓ **of lower activation energy**✓. (2)

3.4.1 C (1)

3.4.2 D (1)

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Question 4

4.1.1 When an external stress is applied to a system in chemical equilibrium✓, the equilibrium point will change in such a way as to counteract the stress✓. (2)

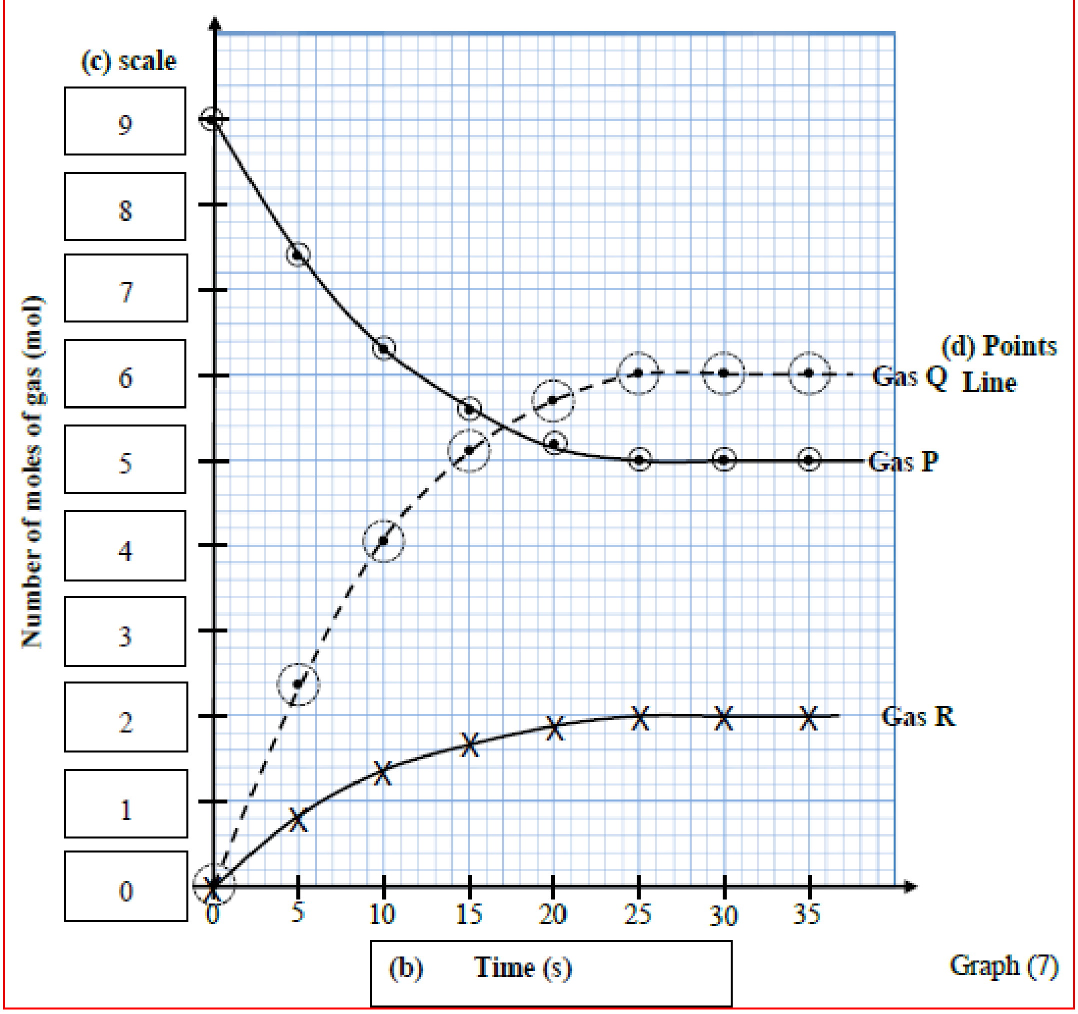
4.1.2 A measure of the extent of a reaction✓, generally measured by comparing the amount of product against the amount of product that is possible. ✓ (2)

4.1.3 Decrease volume of the container✓
This will increase the pressure✓which will favour the forward reaction✓ which produces less moles of gas✓ (and therefore relieves the stress of high pressure. (4)

4.2.1 (a) DCE is reached when the rate of the forward reaction is equal to the rate of the reverse reaction. (1)

(b) There is no change in the number of moles (and hence concentration) of any of the gases after 25 s as shown by the data. (1)

4.2.2 (a) Graph to show the number of moles of gases (P, Q and R) with time
OR Graph of number of moles of gas vs time



Graph (7)

4.2.3 $\underline{2}\,P \rightleftharpoons \underline{3}\,Q + \underline{1}\,R$ (Accept: $4P \rightleftharpoons 6Q + 2R$) (3)

4.2.4 $K_c = \dfrac{[Q]^3 . [R]}{[P]^2}$ c.o.e. from Question 4.2.3 (2)

4.2.5 $K_c = \dfrac{\left[\dfrac{6}{5}\right]^3 . \left[\dfrac{2}{5}\right]}{\left[\dfrac{5}{5}\right]^2}$

<u>Marks</u> n_P = 5 mol c.o.e. from Question 4.2.4
n_Q = 6 mol
n_R = 2 mol
Divide by volume (5 dm^3)

K_c = 0,69

OR

$K_c = \dfrac{(1,2)^3 \cdot (0,4)}{(1)^2}$

K_c = 0,69 (5)

4.2.6 **Low yield** c.o.e. from Question 4.2.5 (1)

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Question 5

5.1 A strong acid ionises almost completely✓ in an aqueous solution, e.g. HY✓
A weak acid ionises partially in an aqueous solution, e.g. H_2X or HZ. (4)

5.2 A monoprotic acid is only able to donate one✓ proton, e.g. HY or HZ. ✓
A polyprotic acid is able to donate more than one proton, e.g. H_2X. (4)

5.3 HY✓ since it has the highest K_a✓ which means it is the strongest acid and would have the highest concentration of H_3O^+ ions. (3)

5.4
$H_2X + 2H_2O \leftrightarrows 2H_3O^+ + X^{2-}$ ions balanced
Or $H_2X + H_2O \leftrightarrows H_3O^+ + HX^-$ ions balanced
(3)

5.5.1 $HZ + NaOH \rightarrow NaZ + H_2O$ (-1 per error) (3)

5.5.2
$n = c \times V$
$= 0{,}1 \times 0{,}0324$ ✓✓
$= 0{,}00324$ mol or $3{,}24 \times 10^{-3}$ mol ✓
(3)

5.5.3
$c = n/V$
$= \frac{0{,}00324}{0{,}025}$
$= 0{,}13\ mol.dm^{-3}$

Alternative (not recommended but will be accepted)
$\frac{C_AV_A}{C_BV_B} = \frac{n_A}{n_B}$
$\frac{C_A \times 25{,}0}{0{,}1 \times 32{,}4} = \frac{1}{1}$
$C_A = 0{,}13\ mol.dm^{-3}$
(3)

5.5.4 Greater than 7✓ Na^+ and OH^- form the strong base NaOH which remains fully dissociated. ✓ Z^- will undergo hydrolysis✓ and (accept protons from water)✓ leading to an excess of OH^- ions. ✓(✓) (5)

5.5.5 (a) Phenolphthalein. (1)

(b) The indicator will change to the end-point or equivalence point colour over the pH range given✓, therefore the final pH of the solution (in this case >7) must fall within the pH range of the indicator✓ (2)

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Question 6

6.1 Electrolyte concentration = 1 $mol \cdot dm^{-3}$ (3)
Temperature = 25 °C
Pressure = 1 atmosphere /101 kPa/1,01 × 10^5 Pa

6.2 $CuSO_4$ / $Cu(NO_3)_2$ / $CuCl_2$ (2)

6.3.1 $Cu \rightarrow Cu^{2+} + 2e^-$ (2)

6.3.2 $Cl_2 + 2e^- \rightarrow 2Cl^-$ (2)

6.3.3 $Cu + Cl_2 \rightarrow Cu^{2+} + 2Cl^-$ (-1 for any error) (2)

6.4 $E^\theta cell = E^\theta cathode - E^\theta anode$ ✓ (4)
$= 1,36 - 0,34$ ✓✓
$= 1,02V$ ✓

6.5 $Cu/Cu^{2+}(1\ mol \cdot dm^{-3}) // C\ell_2 / C\ell^-(1\ mol \cdot dm^{-3}) / Pt$ (4)

✓anode

✓salt bridge

✓cathode

✓Pt

6.6

- Pt is an inert metal (must not react electrochemically in the cell)
- Pt is a good conductor of electricity. (2)

6.7 Potassium chloride/Sodium nitrate (etc.) (2)

6.8

- Anode – increase in concentration of cations.
- Cathode- decrease in concentration of cations ✓
- Ionic imbalance✓
- Cations move into cathode half- cell and anions move into anode half cell✓✓
  OR ions from salt bridge move to each half cell to maintain ionic balance. (4)

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Question 7

7.1 Brine (1)

7.2 To act as an ion-selective✓ membrane which only allows Na^+ ions to pass through into the cathode. ✓ (2)

7.3 $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ (2)

7.4 H_2O is a stronger oxidising agent than ✓ Na^+ (aq) ✓ (2)

7.5 Skills to be marked:

- Minutes to seconds (150s) ✓
- Calculating Q✓
- **Method 1**
  - Mol of e^-✓
  - Mol ratio 1:2✓
  - Mol of Cl_2✓
  - Calculating Volume✓✓
- **Method 2**
  - No. of e^- ✓
  - Calculating mol of e^-✓
  - Mol ratio 1:2✓
  - Calculating volume✓✓ (7)

$Q = It$
$= 4\ 000 \times 150$
$Q = 600\ 000\ C$

$2C\ell^- \rightarrow C\ell_2 + 2e^-$

Method 1

1 mol of $e^- = 96\ 500$ C

$\therefore n(e^-) = \frac{600\ 000}{96\ 500}$

$\therefore n(e^-) = 6{,}22$ mol of e^-

$C\ell_2 : e^-$
1 : 2

$n(C\ell_2) = \frac{6{,}22}{2}$

$\therefore n(C\ell_2) = 3{,}11$ mol of $C\ell_2$

$n = \frac{V}{V_m}$

$V = nV_m$
$= 3{,}11 \times 22{,}4$
$V = 69{,}66\ dm^3$ of $C\ell_2$

Method 2

$1e^- = 1{,}6 \times 10^{-19}C$

$\therefore$ no of $e^- = \frac{600\ 000}{1{,}6 \times 10^{-19}}$

$n(e^-) = 3{,}75 \times 10^{24} e^-$

$n = \frac{N}{N_A}$

$= \frac{3{,}75 \times 10^{24} e^-}{6{,}02 \times 10^{23}}$

$n = 6{,}23$ mol

$C\ell_2 : e^-$
1 : 2

$n(C\ell_2) = \frac{6{,}23}{2}$

$= 3{,}12$

$n = \frac{V}{V_m}$

$V = nV_m$
$= 3{,}12 \times 22{,}4$
$V = 69{,}89\ dm^3$ of $C\ell_2$

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Question 8

8.1.1 B (1)

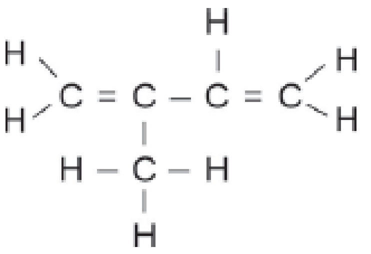
8.1.2 A and F (2)

8.1.3 C and H (must have both, no part marks) (2)

8.2 alcohol (1)

8.3 (4)

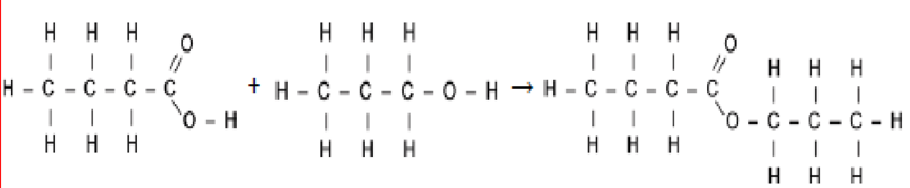
4 carbons in longest chain
Methyl on C_2
Double bond between C_1 & C_2 and between C_3 & C_4
Correct number of H's attached to each C



8.4 2-bromo-3-ethylhexane (4)

(2-bromo) ✓-(3-ethyl) ✓hex✓ane✓

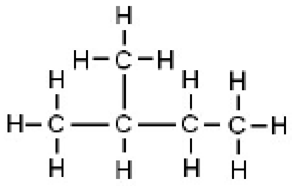
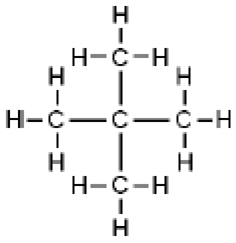
8.5



+ H_2O

Ester linkage✓
Either side of ester linkage✓✓
Reactants✓✓
water✓ (6)

8.6 ONE of the following: (4)

Structural formula (2 marks each)	IUPAC name (2 marks each)
	2-methylbutane (2 is redundant: don't penalise if missing)
	2,2-dimethylpropane (2,2- is redundant: don't penalise if missing)

8.7 Ethanoic acid is able to form **TWO hydrogen bonds**✓ with another ethanoic acid molecule.
Propan-1-ol can only form **ONE** hydrogen✓ bond with another propan-1-ol Molecule.
TWO hydrogen bonds per molecule are collectively **stronger** than ONE✓
More energy is needed to overcome two H-bonds compared with one H-bond therefore, ethanoic acid has a higher boiling point. (4)

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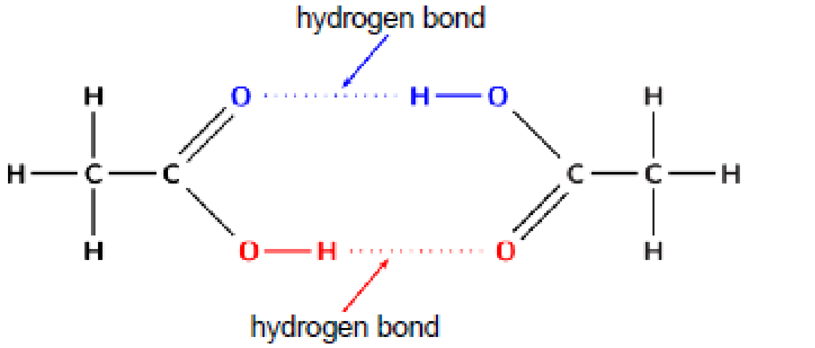

[Source: <https://www.everythingmaths.co.za/science/grade-12>]

Question 9

9.1 X = methanol Y = hex-1-ene Z= ethanoic acid (3)

9.2 $CH_2CHCH_3 + Br_2 \longrightarrow CH_2BrCHBrCH_3$ (3)

Each reactant Product

9.3 $CH_3CH_2CH_2CH_2OH \longrightarrow CH_3CH_2CHCH_2 + H_2O$ (3)

Reactant both Products

[9]