NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2018

PHYSICAL SCIENCES: PAPER II

MARKING GUIDELINES

Time: 3 hours | 200 marks

These marking guidelines are prepared for use by examiners and sub-examiners, all of whom are required to attend a standardisation meeting to ensure that the guidelines are consistently interpreted and applied in the marking of candidates' scripts.

The IEB will not enter into any discussions or correspondence about any marking guidelines. It is acknowledged that there may be different views about some matters of emphasis or detail in the guidelines. It is also recognised that, without the benefit of attendance at a standardisation meeting, there may be different interpretations of the application of the marking guidelines.

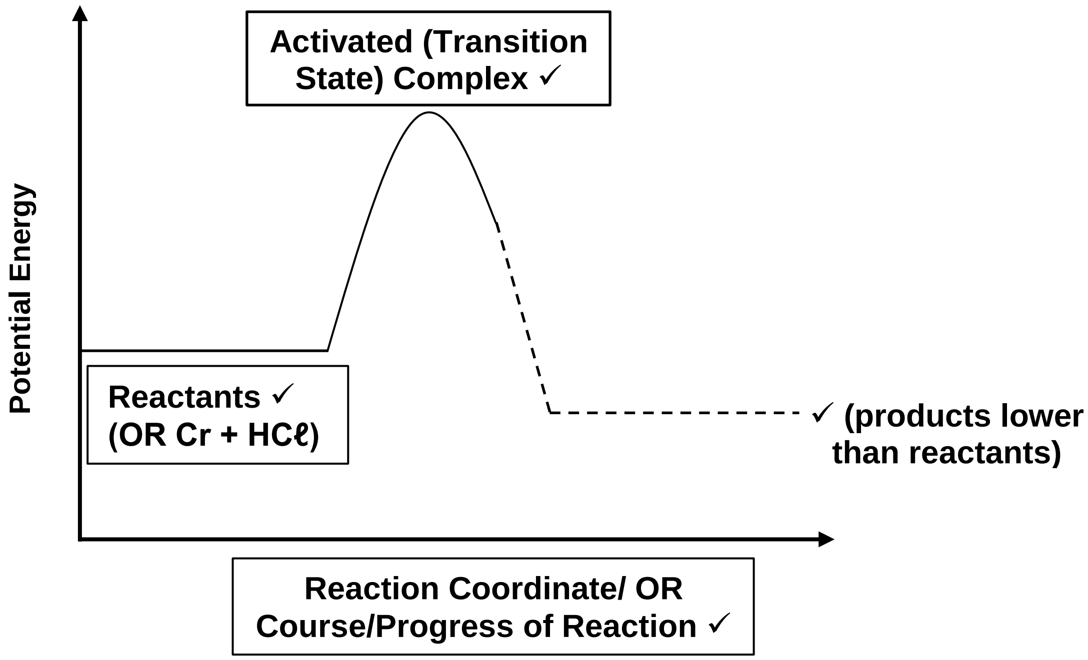
QUESTION 1 MULTIPLE CHOICE

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

[20]

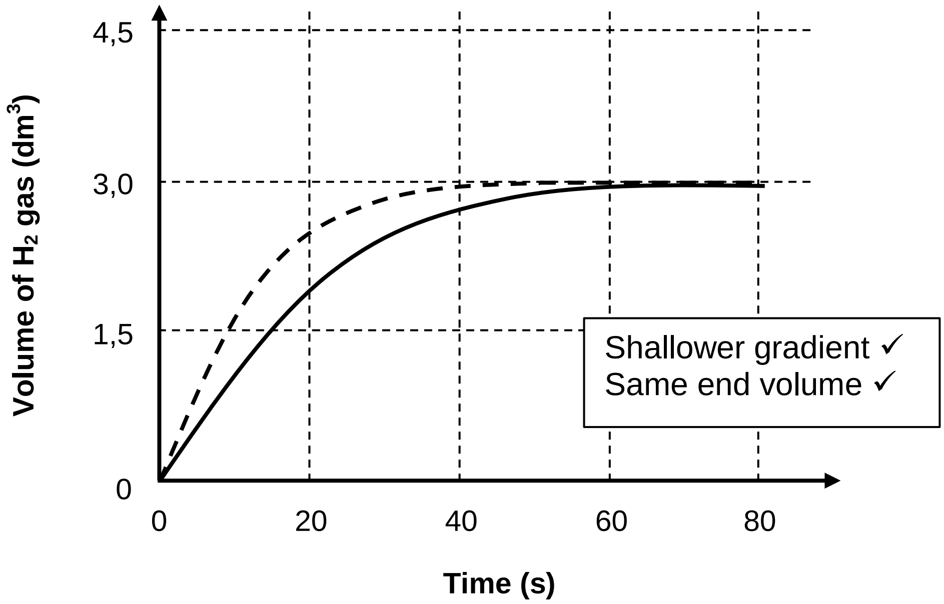
QUESTION 2

2.1



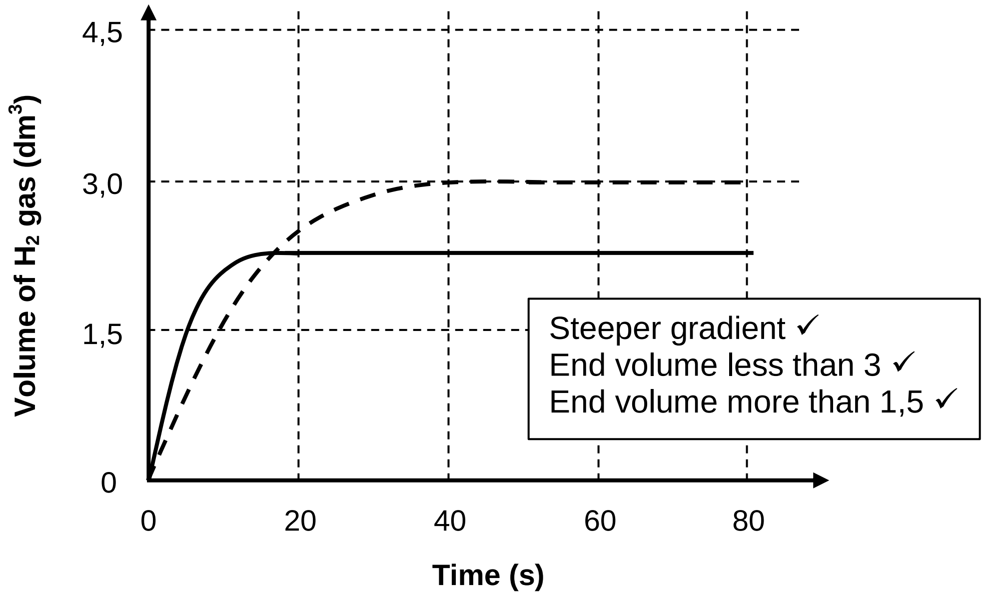
(4)

2.2 2.2.1



(2)

2.2.2



(3)

2.3
- The reaction could be done using a **colorimeter/light meter/spectrophotometer** (OR correct description of apparatus) ✓
- which would **measure the colour intensity of the green solution** (✓) as a measure of **concentration of chromium chloride** (Cr^{3+}) (✓) (either of the points ✓) OR transmittance OR absorbance
- at specific **time** intervals OR over a period of time. ✓

OR
- The reaction could be done on a **mass meter**/scale ✓
- which would measure the **mass of H_2** (lost)/**mass decrease of reaction** ✓
- at specific **time** intervals OR over a period of time. ✓

OR
- A **pH meter** could be used ✓
- To measure the **change (increase) in pH / change (decrease) concentration of H_3O^+** ✓
- at specific **time** intervals OR over a period of time ✓

OR (3)

- A **thermometer** could be used ✓
- to measure the **change (increase) in temperature** ✓
- at specific **time** intervals OR over a period of time ✓

OR

- Relevant equipment is used ✓
- the **time** taken ✓
- for the **Cr(s) to disappear** or the **hydrogen to stop bubbling** ✓ is measured

2.4 2.4.1 $n = \frac{V}{V_m}$ ✓

$n = \frac{(3)}{(22,4)}$ ✓

n = **0,134 mol** ✓ (3)

2.4.2

- $n_{Cr} = \frac{m}{M}$ ✓ $= \frac{(6,0)}{(52)}$ ✓ = 0,1154 mol
- $n_{H_2} = (0,1154) \times \frac{3}{2}$ ✓ = 0,1731 mol
- % Yield = $\frac{\text{actual yield}}{\text{theoretical yield}} \times 100 = \frac{(0,134)}{(0,1731)} \times 100$ ✓
- % Yield = **77,41%** ✓

Alternative:

$VH_2 = 0,1731 \times 22,4$
$= 3,877\ dm^3$

% Yield = $\frac{3}{3,877} \times 100$ ✓
= **77,37%** ✓

Award marks for the following skills:

Equation $n = \frac{m}{M}$ ✓

Substitution into $n = \frac{m}{M}$ ✓

Applying mole ratio ✓
Finding a percentage ✓
Answer in range of **77,2%** to **77,5%** ✓ (5)

2.4.3 Average Rate $= \frac{\Delta V}{\Delta t} = \frac{(3-0)}{(40)}$ ✓ = **0,075 dm³·s⁻¹** ✓ (2)

2.5
- **Correct (favourable) orientation** (alignment) (of the colliding reactant particles) ✓
- (The sum of the) **kinetic energy** (of the reacting particles) is **greater/equal to** than the **activation energy** OR **sufficient kinetic energy**. ✓ (2)

2.6
- (A higher concentration means that) there is a **greater number of particles per unit volume**. ✓
- This **increases** the **number of collisions** that occur **per unit time**. ✓
- This therefore leads to an **increase** in the **number of effective collisions per unit time**, ✓
- leading to a **higher reaction rate**. ✓

Instead of per unit time, accept: frequency OR chance of collisions/effective collisions (4)

2.7 2.7.1 The **sharing** ✓ of (at least one) **pair of electrons** ✓ (by two atoms). (2)

2.7.2 A measure of **the tendency** ✓ (of an atom) to **attract a bonding pair of electrons**. ✓ (2)

2.7.3
- The **difference in electronegativity** between hydrogen and chlorine is **greater than zero**. ✓
- This results in **unequal sharing** ✓ of **electrons**, ✓ i.e. a polar covalent bond OR electrons ✓ spend more time on one atom than another ✓

(If mention is just made of the partially positive and negative poles created then one mark only) (3)

[35]

QUESTION 3

3.1 5 minutes ✓ *(Accept anything between 5 and 6 minutes)* (1)

3.2 $2SO_3 \rightarrow 2SO_2 + O_2$ ✓ (reverse reaction chosen) ✓ (correctly written)
Accept $2SO_2 + O_2 \leftarrow 2SO_3$
(−1 for double arrow) (2)

3.3 When an external stress (change in pressure, temperature or concentration) is applied to a system in **chemical equilibrium**, ✓ the equilibrium point will change in such a way as to **counteract the stress**. ✓ (2)

3.4
- Stress: increase in concentration of O_2
- Le Châtelier's principle predicts the system will **respond in order to decrease the concentration of O_2** (✓)
- Therefore, the **forward reaction** is (initially) **favoured** ✓ as **it consumes O_2** (✓)
- **Decreasing the amount of SO_2** ✓ (3)

3.5 3.5.1 Forward ✓ (1)

3.5.2 Exothermic ✓✓ (2)

3.6 3.6.1 All the concentrations decrease ✓ (since $c = \frac{n}{v}$ and V has increased). (1)

3.6.2
- From the rate equations we see that the rate of the forward reaction is proportional to **cube of concentration** (OR forward rate $\alpha \frac{1}{V^3}$) ✓ whereas the rate of the reverse reaction is proportional to the **square of concentration** (OR reverse rate $\alpha \frac{1}{V^2}$) ✓.
- Therefore the change in pressure (OR volume) has a greater effect on the forward reaction rate than the reverse. (2)

[14]

QUESTION 4

4.1 Increases ✓✓ (2)

4.2 Reverse ✓✓ (2)

4.3 Turns green ✓✓ (2)

4.4 4.4.1 $(K_c =) \dfrac{[CuC\ell_4^{2-}]}{[Cu(H_2O)_6^{2+}][C\ell^-]^4}$ ✓ (top) ✓ (bottom)

(−1 for round brackets)
No marks for inverted (2)

4.4.2 **Concentrations:**

Reaction	$Cu(H_2O)_6^{2+}$	+	$4C\ell^-$	$\rightleftharpoons$	$CuC\ell_4^{2-}$	+	$6H_2O$
Initial concentration	0		0		2 ✓		
Change in concentration	+1,1 ✓		(+4,4		−1,1)	✓	
Equilibrium concentration	1,1		(4,4		0,9) ✓		

OR

Moles:

Reaction	$Cu(H_2O)_6^{2+}$	+	$4C\ell^-$	$\rightleftharpoons$	$CuC\ell_4^{2-}$	+	$6H_2O$
Initial moles	0		0		**4**		
Change in moles	+2,2 ✓		(+8,8		−2,2)	✓	
Equilibrium moles	**2,2**		(8,8		1,8) ✓		
Equilibrium concentration	1,1		4,4		0,9	✓ (÷2)	

Then:

$K_c = \dfrac{[CuC\ell_4^{2-}]}{[Cu(H_2O)_6^{2+}][C\ell^-]^4}$

$K_c = \dfrac{(0,9)}{(1,1)(4,4)^4}$ ✓ (substitution of concentrations)

$K_c = \mathbf{2,18 \times 10^{-3}}$ ✓

Award marks for the following skills:
Finding change in $Cu(H_2O)_6^{2+}$ (either 1,1 or 2,2) ✓
Applying mole ratio to find BOTH of the changes in $C\ell^-$ and $CuC\ell_4^{2-}$ ✓
Finding equilibrium amount/concentration of BOTH $C\ell^-$ and $CuC\ell_4^{2-}$ ✓
Dividing by volume ✓
Substituting concentrations ✓
Answer ✓ (6)

[14]

QUESTION 5

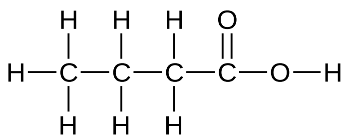
5.1 A proton acceptor. ✓ (1)

5.2 It **dissociates** ✓ (almost) **completely** ✓ (in water/solution). (2)

5.3 KOH ✓ (OR LiOH/RbOH/CsOH/$Ba(OH)_2$/$Sr(OH)_2$ OR any group 1 oxide) (1)

5.4 $NaOH \xrightarrow{(H_2O)} Na^+$ ✓ + OH^- ✓ (2)

5.5
- The **NaOH** solution is more conductive. ✓
- NaOH is **strong** ✓ whilst butanoic acid is weak (OR NaOH dissociates completely, whilst butanoic acid ionises partially)
- It forms **more** ✓ **ions** ✓ (OR higher concentration of ions) in solution (at equal concentrations). (4)

5.6 

4 carbons ✓ Carboxyl group ✓

(2)

5.7 methyl ✓ propanoate ✓ OR ethyl ethanoate OR propyl methanoate
(−1 for no space)

OR but−1−en(e) ✓ −1,1−diol ✓ OR but−1−en(e)−1,2−diol
OR but−1−en(e)−1,3−diol OR but−1−en(e)−1,4−diol
OR but−1−en(e)−2,3−diol OR but−1−en(e)−2,4−diol
OR but−1−en(e)−3,3−diol OR but−1−en(e)−3,4−diol
OR but−1−en(e)−4,4−diol

OR but−2−en(e)−1,1−diol OR but−2−en(e)−1,2−diol
OR but−2−en(e)−1,3−diol OR but−2−en(e)−1,4−diol
OR but−2−en(e)−2,3−diol

enediols **NOT possible**:
but−1−en(e)−2,2−diol
but−2−en(e)−2,2−diol
but−2−en(e)−2,4−diol
but−2−en(e)−3,3−diol
but−2−en(e)−3,4−diol
but−2−en(e)−4,4−diol

(no marks awarded if not an ester or enediol)
(−1 for punctuation errors)
Accept position number in front, e.g. 1−buten(e)−1,3−diol (2)

[14]

QUESTION 6

6.1 Increases ✓ (1)

6.2 $K_w = [H_3O^+][OH^-]$ ✓

(10^{-14}) ✓ $= (6{,}31 \times 10^{-5})$ ✓ $[OH^-]$

$[OH^-] = \mathbf{1{,}58 \times 10^{-10}\ mol{\cdot}dm^{-3}}$ ✓ (4)

6.3 6.3.1 The point where an acid and base have reacted ✓ so neither is in excess (OR exactly according to the mole ratio). ✓ (2)

6.3.2 n_{acid} = **0,0165 mol** ✓ (1)

6.3.3 $V_{acid} = \frac{n}{c} = \frac{0{,}0165}{0{,}21}$ ✓(substitution) ✓ (correct concentration used)

$V_{acid} = 0{,}07857\ dm^3$ ✓

$V_{acid} = \mathbf{78{,}57\ cm^3}$ ✓

(Both answer marks awarded if only cm^3 answer is given.) (4)

6.4 6.4.1 A **reaction with water** ✓ where **water itself is decomposed**. ✓ (2)

6.4.2 There is an **increase** ✓ in **concentration of OH^-**. ✓

(OH^- ions are produced – one mark only)

OR

The **production of OH^- ions** ✓ results in a **decrease in the concentration of H_3O^+** ✓ (due to the upsetting of the equilibrium involving H_3O^+ and OH^- ions in water) (2)

6.5
- This statement is **incorrect** ✓ (awarded without explanation)
- pH depends on the concentration of hydronium ions ✓ (or hydroxide ions)
- which is determined by both strength and concentration of the base ✓ (OR a weak base could have a higher pH than a strong base if it had a much higher concentration ✓ only) (3)

[19]

QUESTION 7

7.1 7.1.1 The substance that accepts/receives/gains electrons ✓ OR a substance that brings about oxidation whilst itself is reduced. (1)

7.1.2
- **$C\ell_2$ is a stronger oxidising agent** (than Ni^{2+}). ✓
- Therefore **$C\ell_2$ is more likely to be reduced** (OR accept/gain/received electrons). ✓ (2)

7.2 7.2.1 The electrode ✓ where oxidation takes place. ✓
(the first mark cannot be given unless the second is) (2)

7.2.2 Ni OR nickel ✓

7.3 Pt OR platinum ✓

7.4 Ni **|** Ni^{2+}(1 mol·dm^{-3}) || $C\ell_2$(1 atm) | $C\ell^-$(1 mol·dm^{-3}) **|** Pt at 25 °C

Oxidation half-cell ✓ Reduction half-cell ✓ Pt electrode (doesn't have to be correctly situated after $C\ell^-$, it must just be shown in the chlorine side of the notation) ✓ Conditions ✓✓ (subtract 1 mark for every mistake)

(5)

7.5 7.5.1 $Ni \rightarrow Ni^{2+} + 2e^-$ ✓✓
(−1 for double arrow) (2)

7.5.2
- The Ni electrode corrodes (loses mass). ✓ *(do not accept dissolves or oxidises)*
- The green colour of the Ni^{2+} electrolyte intensifies/darkens. ✓ (2)

7.5.3 To complete the circuit OR to separate the half-cells ✓ (1)

7.5.4
- Ni^{2+} ions are being produced in this half-cell. (✓)
- Anions enter the electrolyte from the salt bridge (✓)
- and Ni^{2+} cations exit the electrolyte into the salt bridge. (✓)

[Any two of the above points are allocated marks.] (2)

7.6 Increases ✓✓ (2)

[21]

QUESTION 8

For the entire question, the candidate will be penalised once for incorrect usage of terminology of ions, e.g. fluorine ions or oxygen ions.

8.1 It is light. ✓ (1)

8.2 It protects itself from corrosion ✓ (OR it does not corrode easily) (1)

8.3 Anode ✓ (1)

8.4 $A\ell^{3+} + 3e^- \rightarrow A\ell$ ✓✓ (2)

8.5 8.5.1
- Less energy (OR electricity) is used to melt the electrolyte. ✓
- This saves money (cost is less). ✓ (2)

8.5.2
- The cryolite (OR F^- ions) is electrolysed/decomposed. ✓
- This produces perfluorocarbons OR PFCs OR greenhouse gases OR toxic gases OR F_2. ✓
  OR cryolite (or F^-) is itself toxic/harmful to the environment. (1 mark only) (2)

8.6
- O_2 is produced (at the anode). ✓
- This reacts with the carbon electrode (to produce CO_2), causing the electrode to corrode (OR the carbon anode is continually oxidised) ✓
- $C + O_2 \rightarrow CO_2$ ✓✓ OR $2O^{2-} + C \rightarrow CO_2 + 4e^-$
  (IF $2O^{2-} \rightarrow O_2 + 4e^-$ 1 mark only) (4)

8.7 In order to melt aluminium oxide, **many** ✓ **strong** ✓ **ionic** (electrostatic) **forces/bonds** ✓ need to be broken/overcome, which requires **much energy** ✓ (to separate the ions from the crystal lattice). (4)

8.8 8.8.1 $A\ell C\ell_3 + 3$ ✓ $Na \rightarrow A\ell + 3$ ✓ $NaC\ell$
Accept other multiples so long as it is still balanced (2)

8.8.2
- $n_{Na} = 3 \times n_{A\ell} = 3 \times (7{,}56) = 22{,}68$ mol ✓
  (c.o.e. mole ratio from 8.8.1)
- $m_{Na} = nM = (22{,}68)(23)$ ✓ $= 521{,}64\ g$ ✓

Award marks for the following skills:
Applying mole ratio ✓
Multiplying moles of Na by 23 ✓
Answer ✓

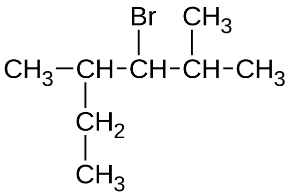
(3)

[22]

QUESTION 9

9.1 9.1.1 3−bromo−2,4−dimethylhexane
3−bromo ✓ −2,4−dimethyl ✓ hex ✓ ane ✓
(−1 for punctuation errors)
(−1 for incorrect order of substituents) (4)

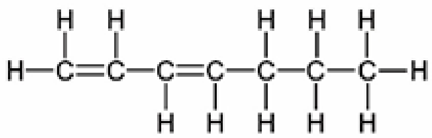
9.1.2 $CH_3CH_2CH(CH_3)CHBrCH(CH_3)CH_3$ ✓✓
OR



(2)

9.2 9.2.1 Alkenes ✓ (1)

9.2.2

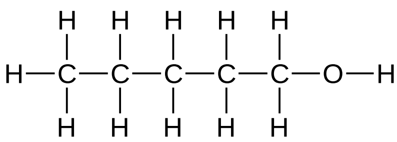


✓(7 carbon straight chain)
✓(double bonds on 1 and 3)
(2)

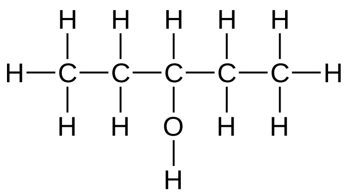
9.3 9.3.1 Hydroxyl ✓ (group) (1)

9.3.2 Molecules with the **same molecular formula** ✓ but **different positions** of their (same) **functional group** ✓ OR (same) branch(es) OR substituent (group). (2)

9.3.3 Any one of the following:



OR



Award marks for the following:
5 carbon <u>straight</u> chain ✓
Hydroxyl group on carbon 1 or 3 ✓

(2)

9.4 9.4.1 A (weak) force of attraction ✓ between molecules or (between) atoms of noble gases. ✓ (2)

9.4.2
- Compound **B** has London forces (only) ✓
- Compound **C** has hydrogen bonding ✓
- Hydrogen bonds are stronger than London forces (OR compound **C** has stronger intermolecular forces) ✓
- It is more difficult for the particles in compound **C** to flow past one another OR more resistance/opposition to flow ✓
- resulting in compound **C** having a higher viscosity (4)

9.5 C_7H_{12} ✓ + $10O_2$ ✓ → $7CO_2$ + $6H_2O$ ✓✓ (balancing)

Award marks for the following:
Formula C_7H_{12} correct ✓
O_2 in reactants ✓
CO_2 and H_2O products ✓
Balancing ✓

(4)

[24]

QUESTION 10

10.1 A compound/molecule containing only ✓ carbon and hydrogen (atoms). ✓ (2)

10.2 Pent✓ane✓ (2)

10.3 10.3.1 Substitution ✓ (halogenation OR chlorination) (1)

10.3.2 Addition ✓ (hydration) (1)

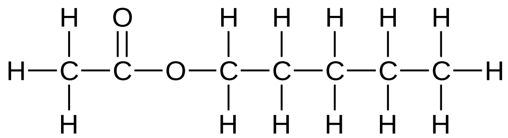
10.3.3 Condensation ✓ (esterification) (1)

10.4 Hydrohalogenation or hydrochlorination ✓ (1)

10.5 Pent−1−ene ✓✓
Accept 1−pentene (2)

10.6 Unsaturated ✓ (1)

10.7 Pentan−1−ol
Pentan ✓
1 ✓
ol ✓
Accept 1−pentanol (3)

10.8  ✓(functional group) ✓(rest of molecule)

(2)

10.9 2 ✓ (1)

[17]

Total: 200 marks