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MARKSCHEME

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CHEMISTRY

Standard Level

Paper 3

12 pages

OPTION A – HIGHER ORGANIC CHEMISTRY

A1. (a) (i) Free radical: species with an ***unpaired electron*** / single electron ***[1]***;
Cl atom / Cl• / C_2H_5• ***[1]***.

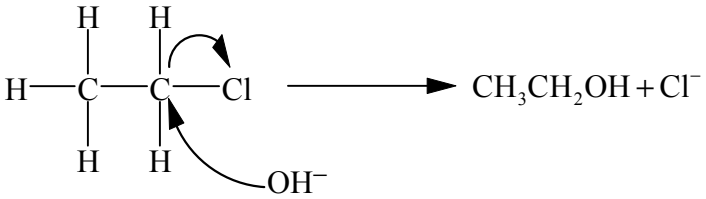
[2 max]

(ii) Homolytic fission: breaking of a (covalent) bond to give two fragments with an electron each. ***[1]***

*(Allow credit for suitable equation **OR** representation.)*

(b) (i) ***Nucleophilic*** substitution / ***nucleophilic*** displacement reaction / S_N1 / S_N2. ***[1]***

(ii)



- Both curly arrows correctly drawn ***[1]***;
- Correct products ***[1]***.

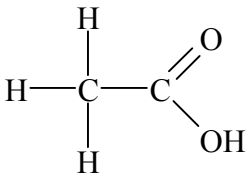
[2 max]

Note:
- *Do not award the first mark if curly arrow originates on the negative charge or on the hydrogen.*
- *Chloride ion must be given for second mark.*

(iii) Bimolecular / molecularity = 2 ***[1]***;
Some reference to **primary** compound / carbon atom (*accept correct reference to reaction not being unimolecular*) ***[1]***.

[2 max]

(c) (i)



(allow CH_3COOH) ***[1]***

Accept CH_3CHO.

(ii) Accept
CH_3COOH is more acidic ***[1]***;
$C=O$ group weakens O—H bond / makes it more polar / attracts electrons from it ***[1]***;
CH_3COO^- anion is more stable / negative charge is delocalised in CH_3COO^- ***[1]***.

If CH_3CHO is chosen in (c) (i), an alternative (ii) is:
CH_3CHO is less acidic / CH_3CH_2OH more acidic ***[1]***;
No polar bonding involving H / no H joined to O ***[1]***;
Effect of C=O not enough to break C–H bond ***[1]***.

[3 max]

(d) (i) Three signals / peaks / absorptions ***[1]***;
Three different proton environments / types of hydrogen (ECF from 1st mark) ***[1]***.

[2 max]

(ii) Ratio 3 : 2 : 1 *(in any order)*. ***[1]***

OPTION B – HIGHER PHYSICAL CHEMISTRY

B1. ***Note: in this question, award consequential marks in (c) and (d) where appropriate.***

(a) Zero order / 0 ***[1]***;
Change in **[Y]** has no effect on rate (provided that there is some reference to experiments 1 and 2 or 0.02 and 0.05) ***[1]***.

[2 max]

(b) Second order / 2 ***[1]***;
(If experiments 1 or 2 are compared with 3.) Change in **[X]** causes rate to increase × 16 ***[1]***.

OR

(If experiments 1 or 2 are compared with 4.) Change in **[X]** causes rate to increase × 9.

[2 max]

(c) Second order / 2 (ECF from (a) and (b)). ***[1]***

(d) Rate = k **[X]**^{2} or k **[X]**^{2}**[Y]**^{0} (ECF from (c)). ***[1]***

(e) Slowest step (accept slow). ***[1]***

B2. (a) (i) Disorder / chaos. ***[1]***

(ii) 1 mol gas $\rightarrow$ 2 mol gas / increase in gas moles ***[1]***;
Therefore going to a more disordered state / gas more disordered than liquid ***[1]***;
Increase (in entropy) / ΔS positive ***[1]***.

[3 max]

(b) (i) Negative / minus. ***[1]***

(ii) Spontaneous. ***[1]***

(iii) Low temperature ***[1]***;
$T\Delta S^{\ominus} < \Delta H^{\ominus}$ or word equivalent ***[1]***.

[2 max]

OPTION C – HUMAN BIOCHEMISTRY

C1. (a) Chemical messenger / OWTTE. ***[1]***

(b) (i) Testes. ***[1]***

*(Note: Do not award **[1]** for ovaries, since in humans the production of testosterone by the ovaries is extremely low in comparison with the testes.)*

(ii) Use (*e.g.* treatment of wasting illness / to regain muscle tissue, treatment of eczema) ***[1]***;
Abuse (*e.g.* increase muscle mass to enhance performance / increase strength) ***[1]***;

Second use or second abuse ***[1]***.

[3 max]

(c) Two groups circled correctly ***[1]***;
Two correct corresponding names ***[1]***.

Accept any two from the following:
- Alkanol / alcohol / hydroxyl;
- Alkene;
- Alkanone / ketone / carbonyl.

(Do not accept CH_3 / methyl / alkyl group or 'hydroxide')

[2 max]

(d) *Allow any one from:*
- Cholesterol has an OH group instead of the $C=O$ group in testosterone;
- Cholesterol has an alkyl / hydrocarbon side-chain instead of the OH group in testosterone;
- There is no carbonyl group present in cholesterol;
- The position of the $C=C$ bond is different in cholesterol compared to testosterone.

(Or any other correct answer, relating to structural differences.)

[1 max]

C2. (a) Glycerol / propane-1,2,3-triol *(accept correct structure).* ***[1]***

(b) Fatty acid(s) / salt of acid / soap / carboxylic acid / alkanoic acid / carboxylate. ***[1]***

(c) Heat with base / alkali / KOH / NaOH (*both needed*). ***[1]***

(d) Heat produced $= (\text{mass} \times \text{specific heat capacity} \times \Delta T)$ *(can be scored by implication)* ***[1]***;
$= (500 \times 4.18 \times 67.5)$ ***[1]***;
$= 141.075$ / 141075 J ***[1]***.

Calorific value of bar $= \frac{50.0}{10.0} \times 141.075$;

$= 705.4$ (kJ) / 705 (kJ) *(accept correct value in J)* ***[1]***.

[4 max]

OPTION D – ENVIRONMENTAL CHEMISTRY

D1. (a) Water / CFCs / dinitrogen oxide (N_2O or nitrous oxide / O_3 / HCFCs / HFCs / SF_6). ***[1]***
(Accept correct formula instead of a name).

(b) (i) *Any two sources, **[1]** each*
e.g. Respiration (by animals) / decay of plants or animals / oxidation of soil humus / forest fires caused by lightning / volcanoes / combustion of fossil fuels and wood / burning trash (rubbish).

[2 max]

(ii) *Any two sources, **[1]** each*
e.g. Bacterial fermentation / bogs or marshes / digestive tracts of ruminants. Rotting waste in land-fill sites.

[2 max]

(c)
- Lower energy / longer wavelength / infrared radiation from the Earth ***[1]***;
- Greenhouse gases absorb / retain / trap this energy ***[1]***;
- Some reference to how the gases absorb this energy *e.g.* vibration ***[1]***.

[3 max]

D2. (a) (i)
- Solid objects / example of this (*e.g.* rock) ***[1]***;
- Grids / screens / sand bed (*do not accept filter*) ***[1]***.

[2 max]

(ii)
- Metal ions / phosphate ***[1]***;
- Alkali / sulfide / Ca^{2+} / calcium ions (accept a named calcium compound) ***[1]***.

[2 max]

(b) (i) *Any two of the following **[1]** each*
- Similar anti-bacterial action achieved with smaller [O_3];
- O_3 more effective than Cl_2 (against waterborne viruses);
- O_3 imparts no chemical taste to water;
- O_3 does not form harmful chlorine containing organic compounds.

[2 max]

(ii) O_3 must be produced on site (because of high reactivity) / O_3 has a shorter retention time. ***[1]***

OPTION E – CHEMICAL INDUSTRIES

E1. (a) **Heats** the furnace / OWTTE ***[1]***.

Any valid reaction involving coke, *e.g.* reduces iron oxide / is converted to carbon monoxide ***[1]***.

[2 max]

(b) (i) Oxygen is blown through (the molten iron). (*Do not accept 'air' here*) ***[1]***;
It oxidises / converts the carbon into carbon dioxide gas (which escapes) ***[1]***.

[2 max]

(ii) Calcium oxide / lime is added (to the molten iron). (*Allow limestone*) ***[1]***;
Calcium oxide reacts (with the silica) to form calcium silicate / slag ***[1]***.

[2 max]

E2. (a) Any appropriate equation (*must have alkane and alkene as products*) ***[1]***;
One use of an alkane (*e.g.* fuel) ***[1]***;
One use of an alkene (*e.g.* polymer or name of polymer) ***[1]***.

[3 max]

(b) (i) Silica / aluminium oxide / zeolites. ***[1]***

(ii) Heat / high temperature / temperature above $300\,^{\circ}C$. ***[1]***

(c) Catalytic cracking produces a mixture of **alkanes and alkenes** ***[1]***;
Hydrocracking produces **alkanes** only ***[1]***.

[2 max]

E3. Any reasonable answer *e.g.* the products of refining are **flammable** and hence there is a risk of fire. ***[1]***

Any reasonable answer *e.g.* the gas produced in the furnace must not be released as it contains poisonous carbon monoxide. ***[1]***

OPTION F – FUELS AND ENERGY

F1. (a) (i) 1 % ***[1]***

(ii) Inappropriate wavelengths ***[1]***;
Reflected / heats the surface / not all areas covered by plants ***[1]***.
[2 max]

(b) (i) Photosynthesis. ***[1]***

(ii) $6H_2O + 6CO_2 \rightarrow C_6H_{12}O_6 + 6O_2$ ***[1]***
(No marks if not balanced.)

(c) (i) *Any two of the following,* ***[1]*** *each*
- Combustion;
- Production of biogas;
- Production of ethanol / fermentation.

[2 max]

(ii) *(Allow* ***[1]*** *for any reasonable advantage and* ***[1]*** *for any reasonable disadvantage.)*
[2 max]

(d) (i)
- Heat ***[1]***;
- Pressure ***[1]***;
- Absence of oxygen ***[1]***.

[3 max]

(ii) *Any three of the following,* ***[1]*** *each*
- Specific example of pollution (*e.g.* oil spills);
- Cost of production / transport;
- Non-renewable;
- More valuable as a feedstock.

[3 max]