

1. (i) Species with an unpaired electron ✓
ALLOW atom, molecule or particle with an unpaired electron
ALLOW 'has an unpaired electron'
ALLOW particle formed by homolytic fission
DO NOT ALLOW particle with a single electron
OR particle with a free electron
1
- (ii) catalyst ✓
1
- (iii) $O + O_2 \rightarrow O_3$
OR O reacts with O_2 to make ozone
OR the reaction is reversible ✓
Rate of formation of ozone is the same as rate of decomposition ✓
ALLOW $O_2 + O \rightleftharpoons O_3$ **OR** $O_3 \rightleftharpoons O_2 + O$ ✓✓
ALLOW is in equilibrium
OR \rightleftharpoons in correct equation
OR has steady state condition ✓
IGNORE other equations involving ozone
2
- (iv) absorbs (harmful) UV ✓
ALLOW 'keeps out UV' **OR** 'filters UV'
ALLOW increased UV could cause skin cancer
OR increased UV could cause cataracts
OR increased UV could cause mutation of crops ✓
IGNORE gamma
1
2. (i) Infrared (radiation absorbed) ✓
by (C–H) bond vibration ✓
ALLOW bond stretching **OR** bond bending
DO NOT ALLOW molecules vibrating
2

[5]

- (ii) Greater concentration of carbon dioxide
OR more carbon dioxide is being made ✓

***ALLOW** carbon dioxide is the main contributor to global warming*

***DO NOT ALLOW** any response that states that CO₂ causes ozone depletion*

***ALLOW** C=O bonds absorb IR more readily than C–H bonds*

***ALLOW** carbon dioxide has a greater greenhouse effect*

1

[3]

3. Any five from the following:

Developing carbon capture **AND** storage ✓

*carbon, capture **AND** storage required*

***ALLOW** CCS*

One example of CCS ✓

Examples of CCS

Second example of CCS ✓

***deep in the oceans **OR** on the sea-bed** ✓*

***DO NOT ALLOW** dissolve CO₂ in the sea **OR** stored in ocean storage in geological formations*

***OR** piped into disused or partially filled oil wells or porous rocks **OR** under the sea-bed ✓*

Provide evidence to governments **OR** international conferences (e.g. Kyoto)
OR reports to United Nations etc ✓

Educating society **OR** writing in journals **OR** producing documentaries
OR writing books **OR** making posters ✓

Monitoring atmospheric changes ✓

by reaction with metal oxides

***OR** reaction to form (solid) carbonates*

***OR** stored as a carbonate*

***OR** equation to show formation of metal carbonate ✓*

***IGNORE** mineral storage*

Develop alternative energy sources ✓
One example of an alternative energy source e.g.
develop fuel cells **OR** developing solar power
OR fuels that do not produce CO₂ ✓

ALLOW idea of biofuels only if linked to carbon-neutrality

(Develop) more efficient engines for transport
OR lean burn engines **OR** hybrid engines **OR** electric cars ✓

IGNORE reforestation
IGNORE reference to CFCs

Find uses for carbon dioxide
OR named use:
e.g. dry cleaning **OR** making decaffeinated coffee
OR blowing agent **OR** fizzy drinks, etc ✓

DO NOT ALLOW use less carbon dioxide

[5]

4. **Any two from the following:**

There are times when CO₂ has a **high** concentration and the temperature is also **high**
OR

There are times when CO₂ has a **low** concentration and the temperature is **low** ✓

ALLOW a (positive) correlation between temperature and carbon dioxide concentration
but DO NOT ALLOW just 'a correlation'

IGNORE 'graphs are the same shape'
IGNORE 'graphs are similar'

It is impossible to measure with certainty the average temperature years ago ✓

There are other gases that may cause a greenhouse effect

OR

There are other factors that may cause a greenhouse effect ✓

There are very few anomalous results ✓

[2]

5. (i) $2\text{CO} + 2\text{NO} \rightarrow 2\text{CO}_2 + \text{N}_2$ ✓

ALLOW any correct multiples including fractions

IGNORE state symbols

1

- (ii) CO and NO are adsorbed (onto surface) **OR** reactants are adsorbed (onto surface) ✓

weakening of bonds **OR** lowers activation energy ✓

CO₂ and N₂ desorbs (from the surface) **OR** products desorbs (from the surface) ✓

*ALLOW CO and NO stick onto surface **OR** CO and NO form weak attractions to the surface **OR** gases are adsorbed onto surface*

*NOT absorb but **allow** ecf for desorb later on*

IGNORE alternative pathway

Requires less energy is not sufficient

*ALLOW products leave the surface **OR** products diffuse away from surface **OR** weak attraction to surface is broken*

ALLOW desorb

3

[4]

6. Any TWO from:

atmospheric concentration ✓

ability to absorb infrared radiation ✓

residence time ✓

*ALLOW the amount of the gas **OR** abundance of gas*

*ALLOW how much IR it absorbs **OR** ability to absorb heat*

IGNORE global warming potential / heat reflected / how much is produced

ALLOW how long it stays in the atmosphere

2

Any TWO from:

deep in the oceans **OR** on the sea-bed ✓

storage in geological formations **OR** under the sea-bed ✓

by reaction (with metal oxides) to form carbonates ✓

ALLOW piped into disused or partially filled oil wells

*ALLOW stored as a carbonate **OR** equation to show formation of suitable carbonate from an oxide*

IGNORE mineral storage

IGNORE reforestation

2

[4]

7. (i) $\text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2$ ✓
 $\text{ClO} + \text{O} \rightarrow \text{Cl} + \text{O}_2$ ✓
overall: $\text{O}_3 + \text{O} \rightarrow 2\text{O}_2$ ✓

OR

- $\text{Cl} + \text{CH}_4 \rightarrow \text{CH}_3 + \text{HCl}$ ✓
 $\text{CH}_3 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}$ ✓
overall: $\text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{HCl}$ ✓

Marks must come from one or other of the radical process and not from both of them.

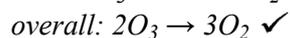
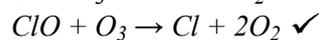
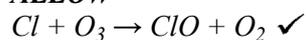
If two processes are described then an incorrect step in one process will contradict a correct step in the other process.

ALLOW overall equation mark even if the steps are wrong

*the radicals do **NOT** need a single dot*

IGNORE any state symbols

ALLOW

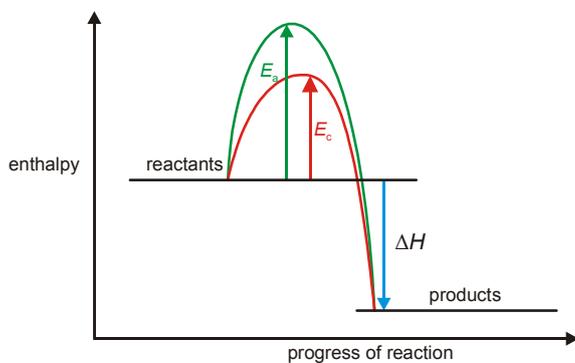


ALLOW any saturated hydrocarbon including cyclic

ALLOW ecf for second step and overall reaction if wrong hydrocarbon used e.g. C_2H_4 is used in first step

3

- (ii) ΔH shown **and** products below reactants ✓
 E_a shown ✓
 E_c shown $< E_a$ ✓



NOT double headed arrows but apply ecf for more than one double headed arrow

ALLOW one mark if two correctly labelled curves are drawn but the arrows are not shown or are incorrectly drawn

The arrows must be positioned as closely as possible to the maximum height of the curves but allow some degree of bod

3

[6]

8. **Any TWO from:**

CFCs take many years to reach the ozone layer **OR** long residence time ✓

CFCs are still being used ✓

there are other ozone depleting substances ✓

IGNORE because chlorine radicals stay in the stratosphere

ALLOW other named ozone depleting substances e.g. NO and HFCs

[2]

9.

O_2

ClO (1) (both needed)

$O_3 + O \rightarrow 2O_2$ (1)

[2]

10. (i) $C_7H_{16} + 11\frac{1}{2} O_2 \rightarrow 7CO_2 + 8H_2O$
 products (1)
 balance (1) 2
- (ii) absorb IR (1)
 C=O bonds vibrate. (1) 2
- [4]**
11. The C–Halogen bond most likely to be broken is C–Br because it is the weakest bond
- [1]**
12. CO from incomplete combustion/ insufficient oxygen ✓
 NO from nitrogen and oxygen in **the air** ✓
- [2]**
13. (i) $ClO + O \rightarrow Cl + O_2$ ✓ 1
- (ii) $O_3 + O \rightarrow 2O_2$ ✓ 1
- (iii) effect of uv radiation/ homolytic fission/
 effect of sunlight ✓ 2
 on CFCs/ on chlorocarbons ✓
- (iv) increase (skin cancer) ✓ 1
- [5]**
14. (a) (i) $C_8H_{18} + 12\frac{1}{2} O_2 \rightarrow 8CO_2 + 9H_2O$
 reagents and products (1)
 balancing (1) 2
- (ii) from nitrogen in air and oxygen (1) 1
- (b) (i) any two from Pt/ Rh/ Pd 1
 (ii) adsorbed (1)
 bonds within molecule weakened (1)
 desorbed/ description (1) 3
- (iii) $CO + NO \rightarrow \frac{1}{2}N_2 + CO_2$
 reagents and products (1)
 balancing (1) 2

(c) ozone/ NO₂/ nitric acid (1)

1

[10]

15. No mark scheme available

16. No mark scheme available