This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners’ meeting before marking began.

All Examiners are instructed that alternative correct answers and unexpected approaches in candidates’ scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

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Section A

A1 (a) vanadium(V) (oxide)
ALLOW: vanadium pentoxide/vanadium oxide/V\textsubscript{2}O\textsubscript{5} [1]

(b) carbon (monoxide)
ALLOW: CO [1]

(c) copper(II) (oxide)
ALLOW: copper oxide/CuO [1]

(d) sulphur dioxide
ALLOW: SO\textsubscript{2} [1]
NOT: sulphur oxide

(e) calcium (oxide)
ALLOW: CaO [1]

[Total: 5]

A2 (a) M, ammonium sulphate = 132, and 2N = 28;
\% = 100 \times \frac{28}{132} = 21 or 21.2 [2]

(b) iron(II) – grey green/green solid or precipitate
(both colour and precipitate needed for the mark)
ALLOW: ppt [1]
iron(III) – red-brown/brown/rust(y)-coloured
(both colour and precipitate needed for the mark)
ALLOW: brick red
NOT: red/pink/reddish/orange/other combinations with red or brown [1]
ALLOW: 1 mark if both colours correct but no reference to precipitate

(c) (i) purple to colourless
ALLOW: purple to (pale) yellow [1]
(ii) (substances whose/atoms/ions/its) oxidation number increases/
oxidation number becomes more positive/
oxidation number becomes less negative/
decreases oxidation number of another substance etc. [1]

(d) (i) \frac{22.5}{1000} \times 0.02 = 4.5 \times 10^{-4} \text{ (moles KMnO}_4\text{)} [1]
(ii) 4.5 \times 10^{-4} \times 5 = 2.25 \times 10^{-3} \text{ (moles Fe}^{2+}\text{)}
2.25 \times 10^{-3} \times 56 = 0.126 \text{ g}
ALLOW: 0.13 g [2]

[Total: 9]
### A3

<table>
<thead>
<tr>
<th>Charge</th>
<th>Ca(^{2+})</th>
<th>Cl(^{-})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protons</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>Neutrons</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Electrons</td>
<td>18</td>
<td>18</td>
</tr>
</tbody>
</table>

| Total: 2 |

### A4

**A and B**

1. **A**

2. **B**

3. **C**

4. **D**

5. **E**

6. **butene**
   - ALLOW: butylene/but-1-ene
   - REJECT: but-2-ene

| Total: 4 |

### A5

**a**

1. **i** Na\(^{+}\) and Cl\(^{-}\) (both required)

2. **ii**
   - Anode: chlorine
   - Cathode: hydrogen

3. **b**
   - Complete circuit with electrodes dipping into electrolyte and cell(s)/(dc) power supply;
   - Impure copper anode/positive electrode and pure copper cathode/negative electrode
   - ALLOW: C\(_2\) or as product of an equation
   - ALLOW: H\(_2\) or as product of equation
   - IF: hydrogen at anode and chlorine at cathode = 1 mark

4. **c**
   - **i** Bauxite
     - ALLOW: alumina/cryolite/diaspore/gibbsite/bőhmite
     - NOT: aluminium oxide

   - **ii** Carbon
     - ALLOW: graphite

| Total: 8 |
A6 (a) (solution) turns brown/orange/yellow
   NOT: black/grey/purple solution/violet gas [1]

(b) \( \text{Cl}_2 + 2\text{KI} \rightarrow 2\text{KCl} + \text{I}_2 \) [1]
   ALLOW: \( \text{Cl}_2 + 2\text{I}^- \rightarrow 2\text{Cl}^- + \text{I}_2 \)

(c) electrons lost/electron loss/electrons removed OWTTE [1]
   ALLOW: oxidation number of iodine increases

(d) (i) No reaction because
   astatine is less reactive than iodine ORA/
   astatine is poorer oxidising agent than iodine ORA/
   astatine releases electrons less well than iodine/
   ALLOW: astatine lower in the group than iodine
   ALLOW: reactivity decreases down the Group [1]
   NOT: astatine less reactive (without reference to iodine/position in Group)

(ii) \( 2\text{Na} + \text{At}_2 \rightarrow 2\text{NaAt} \) [1]
   ALLOW: multiples and \( \text{Na} + \frac{1}{2} \text{At}_2 \rightarrow \text{NaAt} \)

[Total: 5]

A7 (a) carbon dioxide/\( \text{CO}_2 \):
   limewater goes cloudy/white/milky/white precipitate [1]
   (both limewater and result needed for one mark)
   IF: another gas e.g. hydrogen then no marks [1]

(b) \( \text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2 \) [1]
   IGNORE: state symbols
   REJECT: balanced equation with other species on left or right

(c) U – copper
   V – magnesium
   X – calcium
   Y – sodium
   Z – zinc
   correct order = 2 marks

   U – sodium
   V – magnesium
   X – zinc
   Y – copper
   Z – calcium
   order reversed = 1 mark [2]

   reason e.g.
   the more reactive the metal, the longer the time taken to decompose ORA/
   the more reactive the metal, the slower the rate (of decomposition) ORA/
   ALLOW: more reactive metal (carbonates) take longer to decompose
   ALLOW: the more reactive the metal (carbonate) the more stable it is to heat(ing)
   NOT: the metals are in order of the reactivity series [1]

(d) \( 0.01 \times \frac{5}{2} = 0.025 \) [1]
A8 (a) displayed formula for ethanoic acid
   ALLOW: OH in place of O – H
   NOT: CO₂H/COOH for carboxylic acid group
   [1]

(b) \(2\text{Cu} + \text{O}_2 + 4\text{H}^+ \rightarrow 2\text{Cu}^{2+} + 2\text{H}_2\text{O}\)
   correct formulae of reactants and products (1 mark)
   correct balance (2\text{nd} mark)
   [2]

(c) \(M_r\) of \([\text{Cu(CH}_3\text{CO}_2)_2]\text{Cu(OH)}_2 = 462\)
   \(x = 5\)
   [2]

[Total: 5]

Section B

B9 (a) sodium: sodium hydroxide and hydrogen ;
   ALLOW: correct formulae/correct formulae in equation
   NOT: sodium oxide/metallic hydroxide
   magnesium: magnesium hydroxide and hydrogen;
   ALLOW: correct formulae/correct formulae in equation
   NOT: magnesium oxide
   (1 mark can be scored for hydrogen in both of the above OR sodium hydroxide and
magnesium hydroxide in the above)
   sodium reacts (much) faster than magnesium ORA
   ALLOW: any indication from observations e.g. lots of bubbles when sodium reacts with
water and none/hardly any when magnesium reacts
   [1]

(b) correct electronic structure of \(\text{Na}^+\) and \(\text{O}^{2-}\) drawn with charge on top right
   ALLOW: 2,8 and symbol \(\text{Na}^+\) and 2,8 and symbol \(\text{O}^{2-}\)
   REJECT: charges in middle of the atom
   Formula: \(\text{Na}_2\text{O}\)
   [1]

(c) \(4\text{Al} + 3\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3\)
   ALLOW: multiples and \(2\text{Al} + 1\frac{1}{2} \text{O}_2 \rightarrow \text{Al}_2\text{O}_3\)
   [1]

(d) Any two from:
   high melting point or high boiling point
   insoluble in water
   does not conduct electricity/poor electrical conductor/electrical insulator
   does not conduct heat/poor conductor of heat
   ALLOW: solid or hard
   [2]

(e) one physical property: low melting point/low boiling point/poor or non-conductor of
   electricity/poor or non-conductor of heat;
   NOT: gas/liquid
   one chemical property: reacts with water to give acid/reacts with alkalis (or named
alkali) to give salt
   ALLOW: acidic oxide/acidic in nature
   ALLOW: (for acid) \(\text{HCl}/\text{H}_4\text{IO}_4/\text{perchloric acid formed}/(\text{for alkali}) \text{NaC}_i\text{O}_4\)
   [1]

[Total: 10]
B10 (a) \( X \) = activation energy; 
ALLOW: \( E_a \) \[1\]
\( Z \) = enthalpy change (of reaction); 
ALLOW: \( \Delta H \) \[1\]
NOT: energy change/heat given out

(b) (i) energy change is positive/enthalpy change is positive/
energy of 2NO is above that of \( N_2 \) and \( O_2 \)/
ergy of \( N_2 \) and \( O_2 \) is below that of 2NO/
ergy of product(s) is above that of reactants/
ergy of reactants is below that of product(s) \[1\]
NOT: it (unspecified) gains energy
NOT: the product is above the reactants

(ii) bond breaking is endothermic/absorbs energy/takes in energy;  
bond making is exothermic/releases energy/gives out energy;  
more energy is absorbed than released \[1\]
[NOTE: 3\textsuperscript{rd} mark can only be scored if first two marks have been gained]
REJECT: answers in terms of energy involved in bond making/breaking
[more energy absorbed in bond breaking than release in bond making
OWTTE = 3 marks]

(c) (i) activation energy lowered/provides surface for molecules to react/makes the
reaction go by quicker alternative pathway
NOT: allows more frequent collisions \[1\]

(ii) \( 2.4/2 = 1.2 \text{ dm}^3 \) (unit required) \[1\]

(iii) either:
\[
\frac{1.0}{1.2} \times 100 \ (1 \text{ mark}) = 83/83.3\% \ (1 \text{ mark})
\]
ALLOW: ecf from part (ii)
or:
\[
1.0/24 = 0.04166 \ (\text{mol} \ N_2)
m\text{oles} \ NO = 2 \times 0.04166 = 0.0833 \ (\text{moles}) \ (1 \text{ mark})
predicted \text{moles} \ NO = 2.4/24 = 0.1 \ (\text{moles})
100 \times 0.0833/0.1 = 83/83.3\% \ (2\text{nd} \text{mark})
\]

[Total: 10]
### B11 (a)  
\[ C_nH_{2n+1}OH \]  
ALLOW: other letters e.g. \( x \) for \( n \)  
NOT: \( C_nH_{2n+2}O \)  

### (b)  
carbon dioxide and water (both needed)  
ALLOW: correct formulae/steam for water  

### (c)  
#### (i) for first mark  
\[ C_2H_4 + H_2O \rightarrow C_2H_5OH \]  
NOT: \( C_2H_6O \) for ethanol  

#### for second mark  
any two of:  
- high temperature/  
- high pressure/  
- acid catalyst/phosphoric acid  
REJECT: other named acids  
IGNORE: silica/zeolite  

### (ii) either:  
\( M_r \) for glucose 180 and ethanol 46 ;  
180 g glucose → 92 g ethanol;  
\( 36 \times 92/180 = 18.4 \) tonnes (unit needed)  
or:  
moles glucose = \( 36 \times 10^6/180 = 0.2 \times 10^6 \) moles (1 mark)  
\( 0.2 \times 10^6 \) moles glucose → \( 0.4 \times 10^6 \) moles ethanol (1 mark)  
\( 0.4 \times 10^6 \times 46 = 18.4 \) tonnes (1 mark)  

### (iii)  
ethene obtained from crude oil/petroleum/fossil fuels which is a finite resource/  
non-renewable/will run out;  
glucose obtained from plants so continuous supply/renewable resource/won’t run out;  
ALLOW: reasonable named crop plants e.g. beet/wheat  
ALLOW: glucose obtained by photosynthesis in place of plants  
NOT: glucose made with the help of sunlight so renewable  
NOT: because glucose is organic  
(ethene from petroleum and glucose from plants = 1 mark)  

### (d)  
propanoic acid  
ALLOW: propionic acid/correct formula  
ALLOW: propanal  
NOT: propanic acid  

[Total: 10]
B12(a) correct structure of chloroethene showing all atoms and bonds

\[
\begin{array}{c}
\text{H} \\
\mid \\
\text{C} = \text{C} \\
\mid \\
\text{H} \\
\end{array}
\]

\[\text{Cl}\]  [1]

(b) (i) (bond formed) by sharing pair of electrons/two electrons (between the atoms)
NOT: electrons shared between two non metal atoms  [1]

(ii) electrons can’t move/no mobile electrons/electrons not free to move
NOT: no free electrons/no sea of electrons
REJECT: there are no ions or electrons to conduct  [1]

(c) (i) fills up landfill sites quickly/stays a long time in the ground/needs
a lot of landfill sites/takes up a lot of (valuable) land-blocks up drains
ALLOW: can choke animals/fish/birds
[NOT: harms animals/fish/birds]
NOT: explanation of non-biodegradable e.g. does not rot
NOT: not produces harmful fumes when burnt
NOT: land pollution/fills up landfill sites (without qualification)  [1]

(ii) calcium chloride/\text{CaCl}_2  [1]
carbon dioxide/\text{CO}_2  [1]
water/\text{H}_2\text{O}  [1]

(d) (i) correct dot and cross diagram including inner shells of carbon
(paired electrons must be on the overlap areas of the orbits);
inner shells of carbon missing/incorrect number of inner shells = 1 mark maximum  [2]

(ii) 28 tonnes (unit required)  [1]

[Total: 10]