PART 2 **(70 marks = 35% of paper)**

This section has **12** questions. Answer all questions. Write your answers in the space provided.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page
- Continuing an answer. If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued., i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time for this section is 60 minutes.

Question 26 **(1+1=2 marks)**

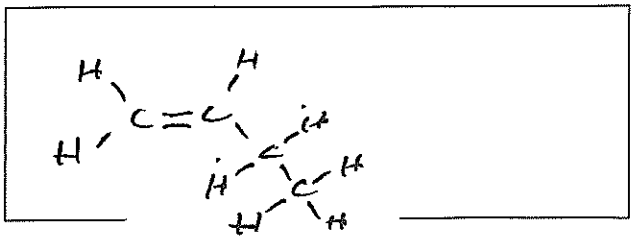
Write equlilibrium constant expressions for the following:

Equation	$4\ NH_3(g) + 5\ O_2(g) \Leftrightarrow 4\ NO(g) + 6\ H_2O(g)$
Equilibrium constant expression	$K = \frac{[NO]^4[H_2O]^6}{[NH_3]^4[O_2]^5}$ ✓

Equation	$PCl_3(l) + Cl_2(g) \Leftrightarrow PCl_5(s)$
Equilibrium constant expression	$K = \frac{1}{[Cl_2]}$ ✓

Question 27 **(2+2= 4 marks)**

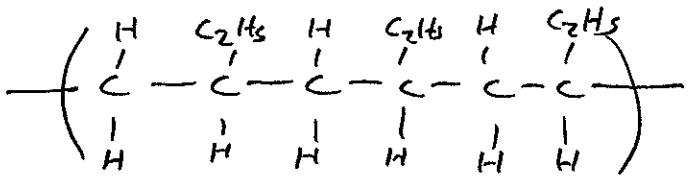
Draw a molecule of 1-butene



✓ for c=c in the right place

✓ for getting the H correct.

1-butene can be polymerized into poly(1-butene). Draw the structure of this polymer, showing all atoms and three repeating units



✓ 6 C chain
✓ $-C_2H_5$ off alternating C

Question 28 **(3+3+3=9 marks)**

Account for the following observations

(a) The melting point of methanal, H_2CO (–21 ^{0}C) is lower than that of methanol, CH_3OH (65 ^{0}C)

✓ both covalent molecular .... mpt. depends upon VDW forces
✓ CH_3OH has disp + H-bonding
✓ H_2CO has disp + dip/dip

(b) The electrical conductivity of liquid magnesium chloride, $MgCl_2$, is greater than that of liquid silicon chloride, $SiCl_4$

$MgCl_2$ is ionic ✓ .. ions can move when molten ✓
$SiCl_4$ is covalent molecular ... no charged particles ✓

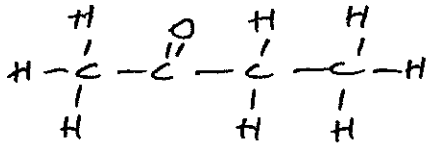
(c) The melting point of silicon dioxide, SiO_2 (1650 ^{0}C) is higher than that of carbon dioxide, CO_2 (–78 ^{0}C).

SiO_2 is covalent network – need to break strong ✓ covalent bonds to melt it.
CO_2 is covalent molecular – only need to break weak VDW forces to melt it. ✓

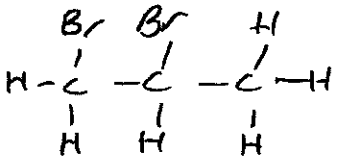
Question 29 **(2+2+2= 6 marks)**

Draw structural formulae and give the IUPAC name for the organic products formed in each of the following reactions. Show all atoms in the structural formula.

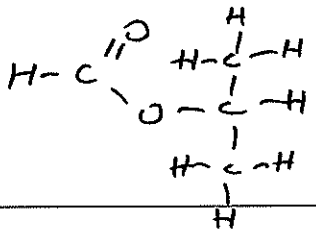
(a) When butan-2-ol is oxidized by acidified $KMnO_4$.

Structure of organic product	Name of organic product
 ✓	butanone ✓

(b) When propene reacts with bromine solution.

Structure of organic product	Name of organic product
 ✓	1,2 dibromopropane ✓

(c) When methanoic acid reacts with propan-2-ol in the presence of $H^+(aq)$

Structure of organic product	Name of organic product
 ✓	2-propylmethanoate ✓

(give 1 mark if 1-propylmethanoate is correctly drawn and named)

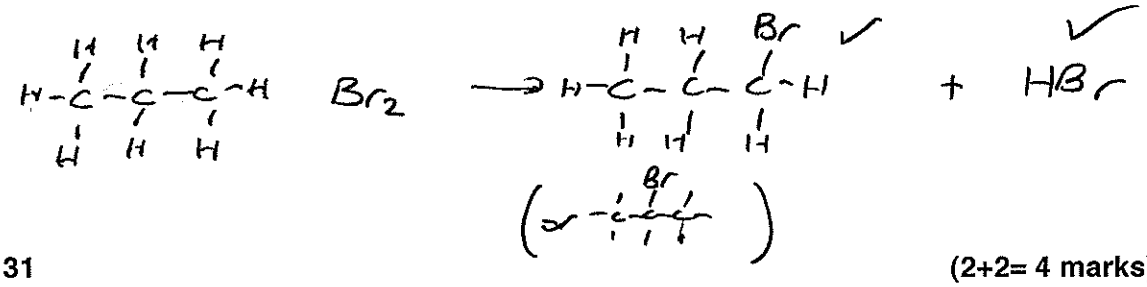
Question 30 **(2+2= 4 marks)**

Write the equation for the reaction that occurs in the following procedures. For full marks, chemical equations should refer only to those species consumed in the reaction and the new species produced. These species may be **ions** [for example $Ag^+_{(aq)}$], **molecules** [for example $NH_{3(g)}$, $NH_{3(aq)}$, $CH_3COOH_{(l)}$] or **solids** [for example $BaSO_{4(s)}$, $Cu_{(s)}$, $Na_2CO_{3(s)}$]

(a) Barium nitrate solution is mixed with sodium phosphate solution

Equation $3Ba^{2+} + 2PO_4^{3-} \rightarrow Ba_3(PO_4)_2$ ✓✓

(b) propane gas is bubbled through bromine water.

Equation  ✓ ✓

Question 31 **(2+2= 4 marks)**

Write observations for any reactions that occur in the following procedures. In each case describe in full what you would observe, including any:

- Colours
- Odours
- Precipitates (give the colour)
- Gases (give the colour or describe as colourless)

(a) Nitric acid is added to copper (II) carbonate.

Observation; green sol.d disappears ✓, colourless odourless gas ✓ is given off, blue solution formed ✓ (-1 for each observation omitted)

(b) Acidified potassium dichromate solution is added to ethanal.

Observation; solution turns from orange ✓ to green ✓, (vinegary smell)

no need for this

Question 32 **(13 marks)**

The graph below represents the concentration of reactants and products at equilibrium for the Haber Process reaction:

$$N_{2(g)} + 3H_{2(g)} \Leftrightarrow 2NH_{3(g)} \qquad \Delta H = -92 \text{ kJmol}^{-1}$$

At equilibrium, there is no change in the concentrations of each component. Sketch the appropriate changes in concentrations of nitrogen and ammonia if:

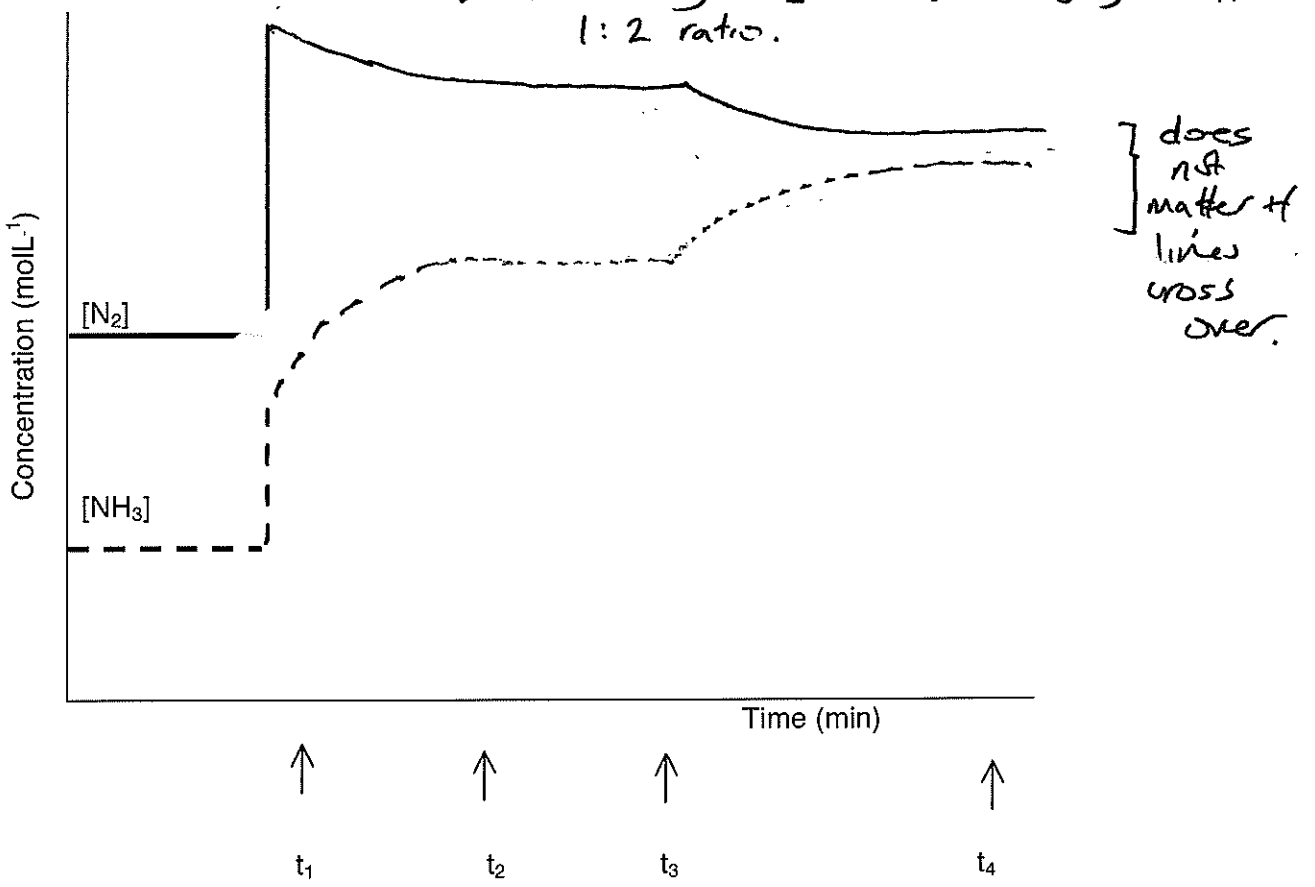
(a) at time t_1 the concentration of volume of the vessel was suddenly halved ✓✓ both lines doubling

(b) at time t_2 equilibrium is restored ✓ N_2 ↓ and NH_3 ↑ ✓ horizontal at t_2

(c) at time t_3 the temperature is decreased ✓ N_2 ↑ ✓ NH_3 ↓

(d) at time t_4 equilibrium is restored ✓ horizontal at t_4 (2+2+2+2=8 marks)

✓ for having N_2 and NH_3 changing in approx 1 : 2 ratio.



The equilibrium constant for the reaction before time t_1 was known. Would the equilibrium constant be higher, lower or the same as it was at the following times (just answer "higher", "lower" or "same")

(e) at the time between t_2 and t_3 same (1 mark) ✓

(f) at the time after t_4 higher (1 mark) ✓

At time t_5 (not shown on graph), a catalyst was added to the system. What would be the effect (write "higher", "lower" or "same") of this addition of a catalyst on:

(g) the equilibrium concentration of NH_3 same (1 mark) ✓

(h) the rate of the forwards reaction higher (1 mark) ✓

(i) the value of the equilibrium constant same (1 mark) ✓

Question 33 **(3+3= 6 marks)**

(a) Describe and explain the trend in the atomic radius of group I elements, moving from Li to Cs.

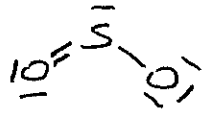
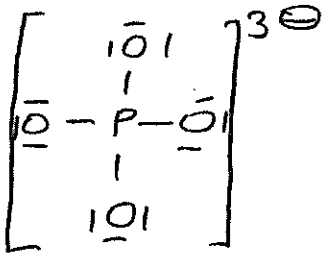
✓ outermost $e^{\ominus}$ become further away and better shielded from nucleus ..... this outweighs the ✓ increase in nuclear charge ... atomic radius increases. ✓

(b) Describe and explain the trend in the electronegativities across period 3, moving from Na to Ar.

nuclear charge is increasing. ✓ $e^{\ominus}$ are being added ✓ to same main shell, so not much increase in shielding. As nuclear charge increases, ability to attract a binding pair of $e^{\ominus}$ ("electronegativity") increases ✓

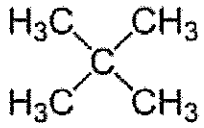
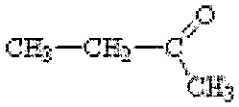
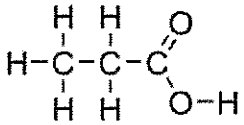
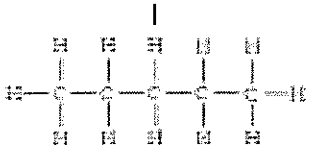
Question 34 **(6 marks)**

For each species listed in the table below, draw the structural formula, representing all valence shell electron electron pairs as either : or – and state the shape of the molecule or ion

Species	Structural formula (showing all valence electrons)	Shape (sketch or name)
sulfur dioxide SO_2	 ✓	 bent (V-shaped) ✓
phosphate ion PO_4^{3-}	 ✓	tetrahedral  ✓
hydrogen cyanide HCN	H – C ≡ N : ✓	linear ✓

Question 35 **(8 marks)**

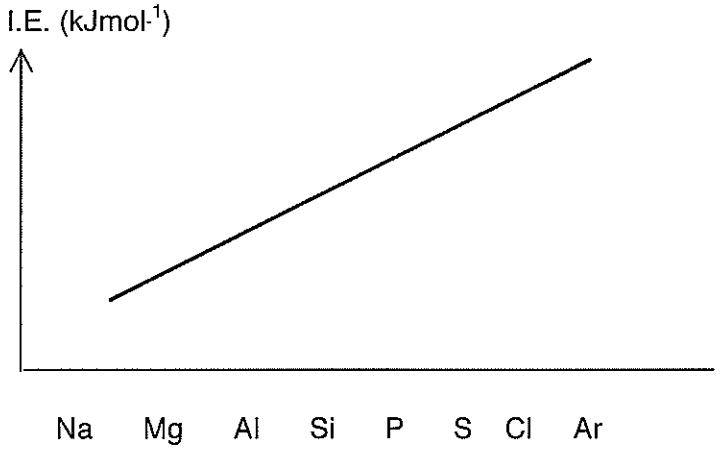
Complete the following table. Note that the molar masses (M) of all substances are in the range of 70-74, and that any differences are insignificant.

Molecule	Major type of intermolecular attraction.(choose from dispersion forces, dipole-dipole forces or hydrogen bonding)	Boiling point ranking (1=highest, 4=lowest)
 dimethylpropane	dispersion ✓	4 ✓
 butanone	dipole/dipole ✓	2 ✓
 propanoic acid	H-bonding ✓	1 ✓
 pentane	dispersion ✓	3 ✓

Question 36 **(2+3+3=8marks)**

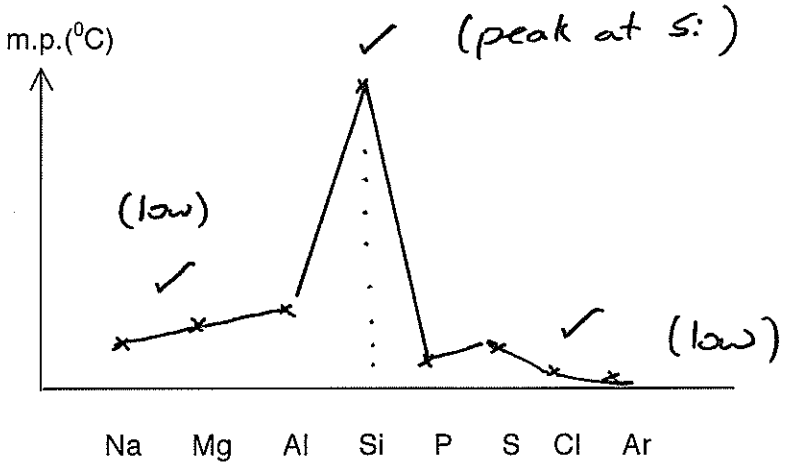
Sketch the following graphs:

(a) the first ionisation energies of the period 3 elements

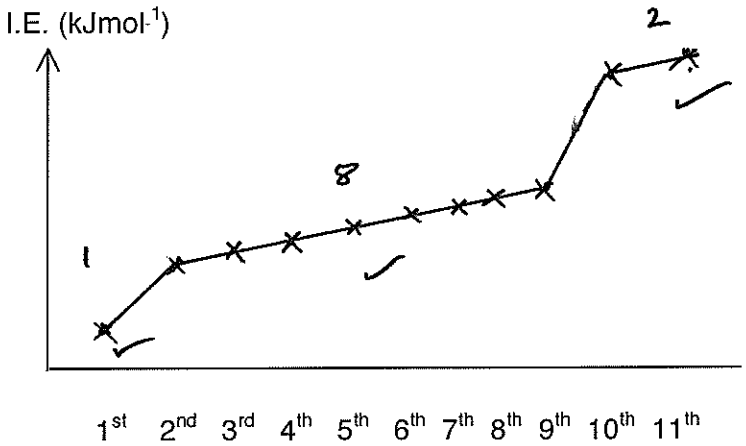


✓✓ (generous!)

(b) the melting points of the period 3 elements



(c) the eleven ionisation energies of sodium



END OF PART TWO