Combined science chemistry transition work: exam booklet

Name: _____

Class: _____

Date: _____

Time: **120 minutes**

Marks: **99 marks**

Q1.

This question is about metals and the reactivity series.

(a) Which **two** statements are properties of most transition metals?

Tick (✓) **two** boxes.

They are soft metals.	☐
They form colourless compounds.	☐
They form ions with different charges.	☐
They have high melting points.	☐
They have low densities.	☐

(2)

(b) A student added copper metal to colourless silver nitrate solution.

The student observed:

- pale grey crystals forming
- the solution turning blue.

Explain how these observations show that silver is less reactive than copper.

_____

_____

_____

_____

_____

_____

(3)

(c) A student is given three metals, **X**, **Y** and **Z** to identify.

The metals are magnesium, iron and copper.

Plan an investigation to identify the three metals by comparing their reactions with dilute hydrochloric acid.

Your plan should give valid results.

(4)

(d) Metal **M** has two isotopes.

The table below shows the mass numbers and percentage abundances of the isotopes.

Mass number	Percentage abundance (%)
203	30
205	70

Calculate the relative atomic mass (A_r) of metal **M**.

Give your answer to 1 decimal place.

Relative atomic mass (1 decimal place) = _____

(2)

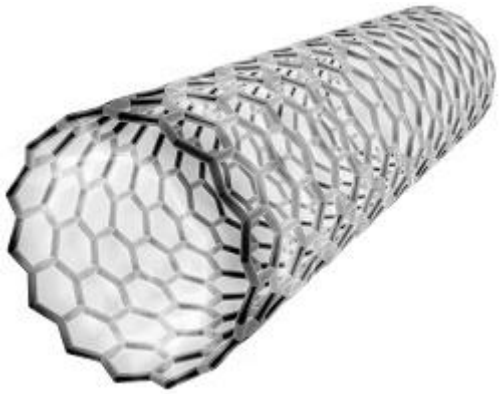
(Total 11 marks)

Q2.

This question is about materials and their properties.

(a) **Figure 1** shows a carbon nanotube.

Figure 1



The structure and bonding in a carbon nanotube are similar to graphene.

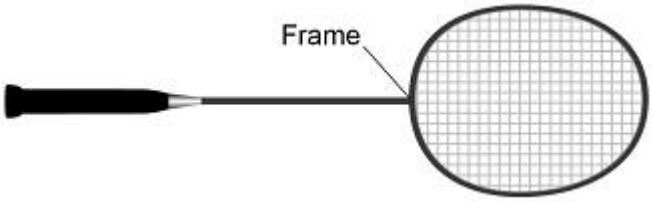
Carbon nanotubes are used in electronics because they conduct electricity.

Explain why carbon nanotubes conduct electricity.

(2)

(b) **Figure 2** shows a badminton racket.

Figure 2



The following table shows some properties of materials.

The materials could be used to make badminton racket frames.

Material	**Density in g/cm^3**	**Relative strength**	**Relative stiffness**
Aluminium	2.7	0.3	69
Carbon nanotube	1.5	60	1000
Wood	0.71	0.1	10

Evaluate the use of the materials to make badminton racket frames.

Use the table above.

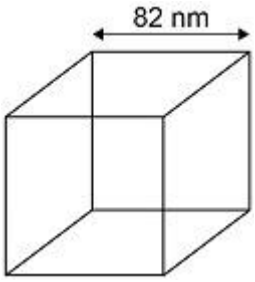
(4)

Zinc oxide can be produced as nanoparticles and as fine particles.

(c) A nanoparticle of zinc oxide is a cube of side 82 nm

Figure 3 represents a nanoparticle of zinc oxide.

Figure 3



Calculate the surface area of a nanoparticle of zinc oxide.

Give your answer in standard form.

Surface area = _____ nm^2

(1)

(d) Some suncreams contain zinc oxide as nanoparticles or as fine particles.

Suggest **one** reason why it costs less to use nanoparticles rather than fine particles in suncreams.

_____

_____

(1)

(Total 10 marks)

Q3.

This question is about organic compounds.

(a) Butane is an alkane with small molecules.

Complete the sentence.

Choose the answer from the box.

fertiliser	**formulation**	**fuel**

Butane can be used as a _____.

(1)

(b) Poly(propene) is a polymer.

What is the name of the monomer used to produce poly(propene)?

Tick (✓) **one** box.

Propane	☐
Propanoic acid	☐
Propanol	☐
Propene	☐

(1)

Ethene and steam react to produce ethanol.

The equation for the reversible reaction is:

ethene + steam ⇌ ethanol

(c) The reaction produces a maximum theoretical mass of 400 kg of ethanol from 243 kg of ethene and 157 kg of steam.

A company produces 380 kg of ethanol from 243 kg of ethene and 157 kg of steam.

The percentage yield of ethanol is less than 100%

Calculate the percentage yield of ethanol.

Use the equation:

$$\text{percentage yield of ethanol} = \frac{\text{mass of ethanol actually made}}{\text{maximum theoretical mass of ethanol}} \times 100$$

_____

_____

Percentage yield = _____ %

(2)

(d) What are **two** possible reasons why the percentage yield of ethanol is less than 100%?

Tick (✓) **two** boxes.

Ethanol is the only product of the reaction.	☐
Ethanol is very unreactive.	☐
Some ethanol changes back into ethene and steam.	☐
Some ethanol escapes from the apparatus.	☐
Some ethanol reacts with steam.	☐

(2)

(e) Ethanol burns in oxygen.

Balance the equation for the reaction.

$$C_2H_5OH + \_\_\_ O_2 \rightarrow 3\ H_2O + 2\ CO_2$$

(1)

(f) Two processes for producing ethanol are:

- fermentation
- hydration (reacting ethene with steam).

The table below shows information about the processes.

Feature	**Process**	
	Fermentation	**Hydration**
Raw material	sugar	crude oil
Energy usage	low	high

Rate of reaction	slow	fast
Purity of ethanol	15%	98%

Give **two** advantages and **two** disadvantages of using fermentation to produce ethanol.

Advantage of fermentation 1 _____

_____

Advantage of fermentation 2 _____

_____

Disadvantage of fermentation 1 _____

_____

Disadvantage of fermentation 2 _____

_____

(4)

(Total 11 marks)

Q4.

This question is about the reaction between hydrogen sulfide (H_2S) and oxygen.

The equation for the reaction is:

$$2\ H_2S(g) + 3\ O_2(g) \rightarrow 2\ H_2O(g) + 2\ SO_2(g)$$

(a) What does $H_2O(g)$ represent?

_____

(1)

(b) Calculate the volume of oxygen required to react with 50 cm^3 of hydrogen sulfide.

_____

_____

Volume = _____ cm^3

(1)

(c) **Figure 1** shows part of the reaction profile for the reaction.

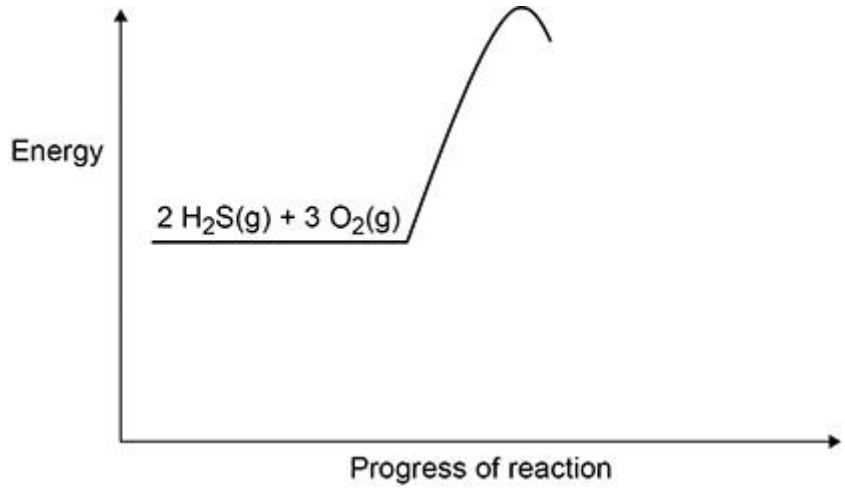
The reaction is exothermic.

Complete **Figure 1**.

You should:

- complete the profile line
- label the activation energy
- label the overall energy change.

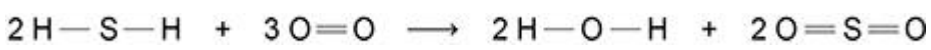
Figure 1



(3)

(d) **Figure 2** shows the displayed formula equation for the reaction of hydrogen sulfide with oxygen.

Figure 2



The table below shows some of the bond energies.

Bond	H — S	O = O	H — O	S = O
Energy in kJ/mol	364	498	464	**X**

In the reaction the energy released forming new bonds is 1034 kJ/mol greater than the energy needed to break existing bonds.

Calculate the bond energy **X** for the bond.

Use **Figure 2** and the table above.

_____

_____

_____

X = _____kJ/mol

(5)

(Total 10 marks)

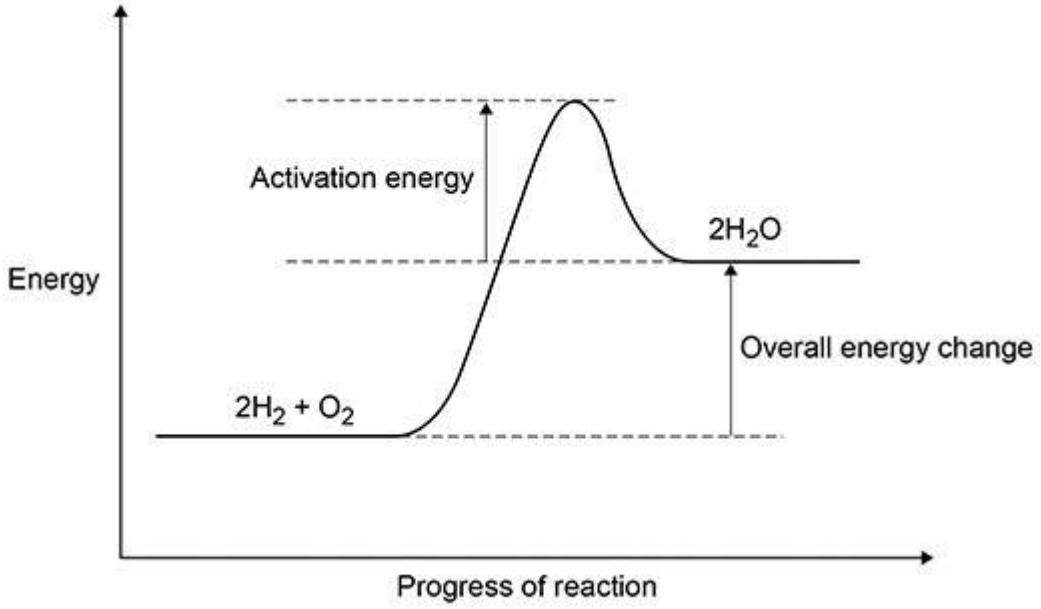
Q5.

The reaction between hydrogen and oxygen releases energy.

(a) A student drew a reaction profile for the reaction between hydrogen and oxygen.

Figure 1 shows the student's reaction profile.

Figure 1



The student made **two** errors when drawing the reaction profile.

Describe the **two** errors.

1 _____

_____

2 _____

_____

(2)

(b) The reaction between hydrogen and oxygen in a hydrogen fuel cell is used to produce electricity.

Hydrogen fuel cells and rechargeable cells are used to power some cars.

Give **two** advantages of using hydrogen fuel cells instead of using rechargeable cells to power cars.

1 _____

_____

2 _____

_____

(2)

(c) Reactions occur at the positive electrode and at the negative electrode in a hydrogen fuel cell.

Write a half equation for **one** of these reactions.

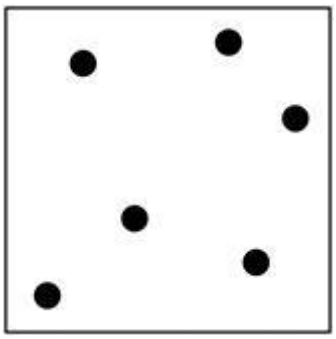
_____

(1)

(d) The three states of matter can be represented by a simple particle model.

Figure 2 shows a simple particle model for hydrogen gas.

Figure 2



Give **two** limitations of this simple particle model for hydrogen gas.

1 _____

_____

2 _____

_____

(2)

(e) The hydrogen gas needed to power a car for 400 km would occupy a large volume.

Suggest **one** way that this volume can be reduced.

_____

_____

(1)

(f) The energy needed for a car powered by a hydrogen fuel cell to travel 100 km is 58

megajoules (MJ).

The energy released when 1 mole of hydrogen gas reacts with oxygen is 290 kJ

The volume of 1 mole of a gas at room temperature and pressure is 24 dm^3

Calculate the volume of hydrogen gas at room temperature and pressure needed for the car to travel 100 km

Volume of hydrogen gas = _____ dm^3

(4)

(Total 12 marks)

Q6.

This question is about carboxylic acids.

Carboxylic acids belong to a homologous series.

The table below shows information about the first three carboxylic acids in this homologous series.

Name	**Formula**	**pH of a 0.01 mol/dm^3 solution**
Methanoic acid		2.91
Ethanoic acid	CH_3COOH	3.39
	CH_3CH_2COOH	3.44

(a) Complete the table above.

(2)

(b) Ethanoic acid ionises in water.

The equation for the reaction is:

$$CH_3COOH(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$$

Explain how the equation shows that ethanoic acid is a weak acid.

(2)

(c) A student adds a solution of ethanoic acid to zinc carbonate in an open flask on a balance.

Explain what happens to the mass of the flask and its contents during the reaction.

(3)

(d) The student compares the rates of the reaction of zinc carbonate with:

- 0.01 mol/dm^3 methanoic acid
- 0.01 mol/dm^3 ethanoic acid.

The rate of the reaction with methanoic acid is greater than the rate of the reaction with ethanoic acid.

Explain why.

You should refer to ions in your answer.

Use the table above.

(3)

Ethanoic acid reacts with ethanol to produce an ester.

(e) Give the name of the ester produced when ethanoic acid reacts with ethanol.

_____

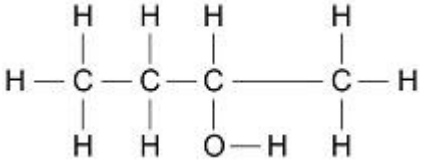
(1)

(f) Hexanedioic acid and ethanediol join together to produce a polyester.

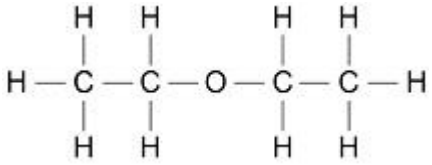
Ethanoic acid and ethanol join together in the same way to produce an ester.

Which is the displayed structural formula of the ester produced when ethanoic acid reacts with ethanol?

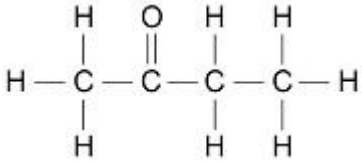
Tick (✓) **one** box.



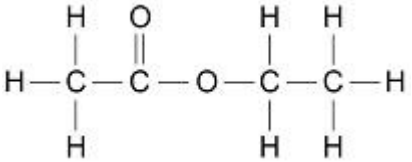
☐



☐



☐



☐

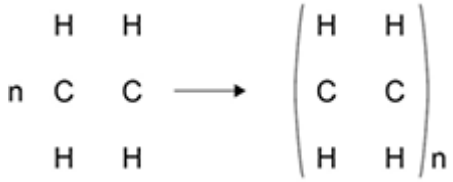
(1)

(Total 12 marks)

Q7.

Ethene is used to produce poly(ethene).

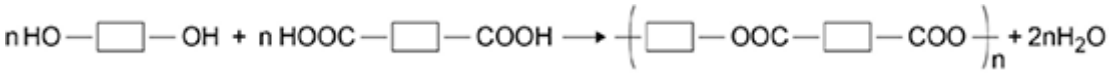
(a) Draw the bonds to complete the displayed formulae of ethene and poly(ethene) in the equation.



(2)

(b) Polyesters are made by a different method of polymerisation.

The equation for the reaction to produce a polyester can be represented as:



Compare the polymerisation reaction used to produce poly(ethene) with the polymerisation reaction used to produce a polyester.

(4)

(Total 6 marks)

Q8.

Potash alum is a chemical compound.

The formula of potash alum is $KAl(SO_4)_2$

(a) Give a test to identify the Group 1 metal ion in potash alum.

You should include the result of the test.

Test _____

Result _____

(2)

(b) Name **one** instrumental method that could identify the Group 1 metal ion **and** show the concentration of the ion in a solution of potash alum.

(1)

A student identifies the other metal ion in potash alum.

The student tests a solution of potash alum by adding sodium hydroxide solution until a change is seen.

(c) Give the result of this test.

_____

_____

(1)

(d) This test gives the same result for several metal ions.

What additional step is needed so that the other metal ion in potash alum can be identified?

Give the result of this additional step.

Additional step _____

_____

Result _____

_____

(2)

(e) Describe a test to identify the presence of sulfate ions in a solution of potash alum.

Give the result of the test.

Test _____

_____

_____

Result _____

_____

_____

(3)

(Total 9 marks)

Q9.

This question is about alloys.

Bronze and brass are both alloys which contain copper.

(a) Bronze is an alloy of copper and one other metal.

What is the other metal in bronze?

Tick (✓) **one** box.

Aluminium ☐

Tin ☐

Zinc ☐

(1)

(b) Give **one** use of brass.

_____

_____

(1)

Alloys of gold are used to make jewellery.

(c) The proportion of gold in an alloy is measured in carats:

- pure gold is 24 carat
- 50% gold is 12 carat.

The table below shows information about two gold rings, **A** and **B**.

A and **B** contain only gold and silver.

Complete below the table below.

Gold ring	**Carat**	**Mass of metal in grams**	
		gold	silver
A		7	7
B	18	9	

(2)

(d) Suggest **two** reasons why alloys of gold are used instead of pure gold to make jewellery.

1 _____

_____

2 _____

_____

(2)

Steels are alloys of iron.

(e) Spoons are made of stainless steel.

Spoons:

- are washed after use
- must not wear away quickly.

Suggest **one** reason why stainless steel is suitable for making spoons.

_____

_____

(1)

(f) Steel horseshoes are shaped to fit the feet of horses.

Which type of steel is most easily shaped into horseshoes?

Tick (✓) **one** box.

High carbon steel	☐
Low carbon steel	☐
Stainless steel	☐

(1)

(Total 8 marks)

Q10.

This question is about reversible reactions and equilibrium.

Hydrogen is used to produce ammonia in the Haber process.

The hydrogen is made in two stages.

Stage 1 is the reaction of methane and steam to produce carbon monoxide and hydrogen.

The equation for the reaction is:

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3\ H_2(g)$$

(a) Calculate the atom economy for the formation of hydrogen in **stage 1**.

Relative atomic masses (A_r): H = 1 C = 12 O = 16

_____

_____

_____

_____

Atom economy = _____%

(2)

(b) Explain why a low pressure is used in **stage 1**.

Give your answer in terms of equilibrium.

_____

_____

_____

_____

(2)

(c) **Stage 2** uses the carbon monoxide produced in **stage 1**.

The carbon monoxide is reacted with more steam to produce carbon dioxide and more hydrogen.

The equation for the reaction in **stage 2** is:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

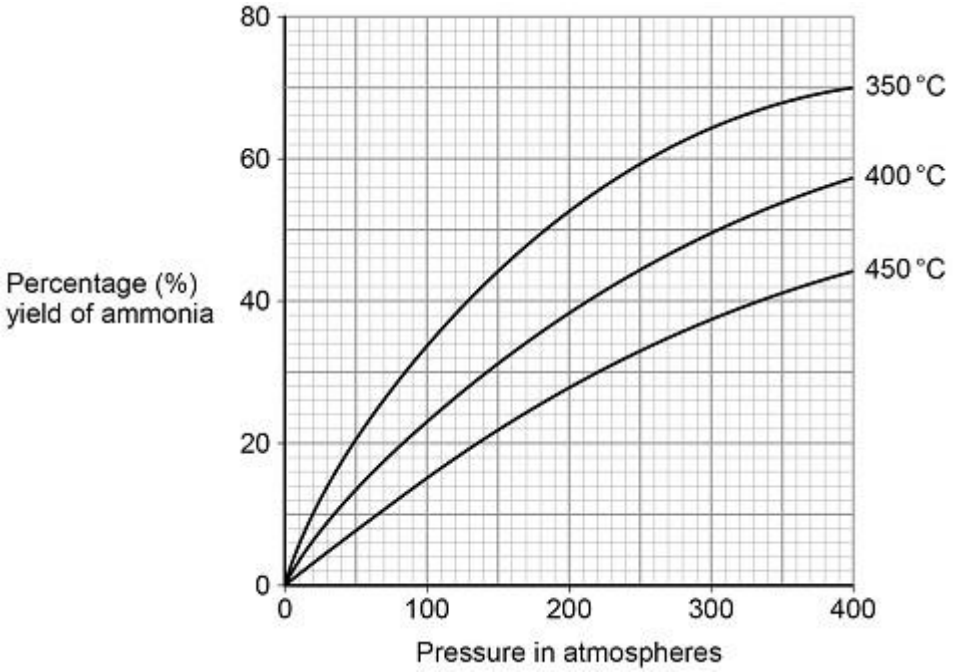
What is the effect of increasing the pressure on the equilibrium yield of hydrogen in **stage 2**?

_____

_____

(1)

The graph below shows the percentage yield of ammonia produced at different temperatures and pressures in the Haber process.



A temperature of 450 °C and a pressure of 200 atmospheres are used in the Haber process.

(d) A student suggested that a temperature of 350 °C and a pressure of 285 atmospheres could be used instead of those used in the Haber process.

Determine how many times greater the percentage yield of ammonia obtained would be.

Use the graph.

_____

_____

_____

_____

Percentage yield = _____ times greater

(3)

(e) A pressure of 285 atmospheres is **not** used in the Haber process instead of 200 atmospheres.

Give **one** reason why.

_____

_____

(1)

(f) How does the graph above show that the forward reaction in the Haber process is exothermic?

_____

_____

(1)

(g) World production of ammonia is now about 30 times greater than it was in 1950.

Suggest why the demand for ammonia has increased.

_____

_____

_____

_____

(2)

(Total 12 marks)