C3a Higher 2

50 minutes

50 marks

Q1. The colours of fireworks are produced by chemicals.

(a) Information about four chemicals is given in the table.

Complete the table below.

Chemical	Colour produced in firework
barium chloride	green
..... carbonate	crimson
sodium nitrate	.....
calcium sulfate	red

(2)

(b) Describe a test to show that barium chloride solution contains chloride ions.

Give the result of the test.

.....

.....

.....

.....

(2)

(c) A student did two tests on a solution of compound **X**.

Test 1
Sodium hydroxide solution was added.
A blue precipitate was formed.

Test 2
Dilute hydrochloric acid was added.
Barium chloride solution was then added.
A white precipitate was formed.

The student concluded that compound **X** is iron(II) sulfate.

Is the student's conclusion correct?

Explain your answer.

.....

.....

.....

.....

.....

.....

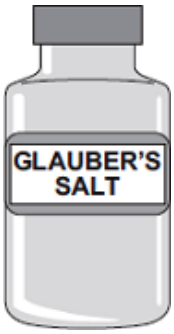
(3)
(Total 7 marks)

Q2. Four bottles of chemicals made in the 1880s were found recently in a cupboard during a Health and Safety inspection at Lovell Laboratories.

Sodium carbonate

Sodium chloride

Sodium nitrate



Sodium sulfate

The chemical names are shown below each bottle.

(a) You are provided with the following reagents:

- aluminium powder
- barium chloride solution acidified with dilute hydrochloric acid
- dilute hydrochloric acid
- silver nitrate solution acidified with dilute nitric acid
- sodium hydroxide solution.
- limewater
- red litmus paper

(i) Describe tests that you could use to show that these chemicals are correctly named.

In each case give the reagent(s) you would use **and** state the result.

Test and result for carbonate ions:

.....

.....

.....

Test and result for chloride ions:

.....

.....

.....

Test and result for nitrate ions:

.....

.....

.....

Test and result for sulfate ions:

.....

.....

.....

(4)

(ii) Suggest why a flame test would **not** distinguish between these four chemicals.

.....

(1)

(b) Instrumental methods of analysis linked to computers can be used to identify chemicals.

Give **two** advantages of using instrumental methods of analysis.

.....

.....

.....

.....

(2)
(Total 7 marks)

Q3. A student carried out a titration to find the concentration of a solution of hydrochloric acid. The following paragraph was taken from the student's notebook.

I filled a burette with hydrochloric acid. 25.0 cm^3 of 0.40 mol/dm^3 potassium hydroxide was added to a flask. 5 drops of indicator were added. I added the acid to the flask until the indicator changed colour. The volume of acid used was 35.0 cm^3.

(a) What piece of apparatus would be used to measure 25.0 cm^3 of the potassium hydroxide solution?

.....

(1)

(b) Name a suitable indicator that could be used.

.....

(1)

(c) Calculate the number of moles of potassium hydroxide used.

.....

.....

Moles of potassium hydroxide = ... mol

(2)

(d) Calculate the concentration of the hydrochloric acid. The equation for the reaction is:

$KOH + HCl \rightarrow KCl + H_2O$

.....

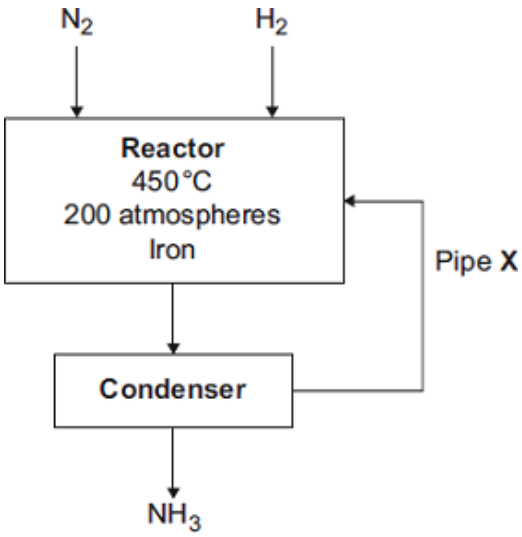
.....

.....

Concentration of hydrochloric acid = ... mol/dm^3

(2)
(Total 6 marks)

Q4. The flow diagram shows the Haber process. In the Haber process, ammonia (NH_3) is produced from nitrogen (N_2) and hydrogen (H_2).



(a) Which raw material is nitrogen obtained from?

.....

(1)

(b) What is the purpose of Pipe **X**?

.....

.....

.....

.....

(2)

(c) Balance the chemical equation below for the production of ammonia.

N_2 + ...H_2 ⇌ .....NH_3

(1)

(d) A temperature of 450°C is used in the reactor.
The reaction of nitrogen with hydrogen is reversible.
The forward reaction is exothermic.

Explain why a temperature of 450°C is the optimum temperature for the Haber process.

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.....

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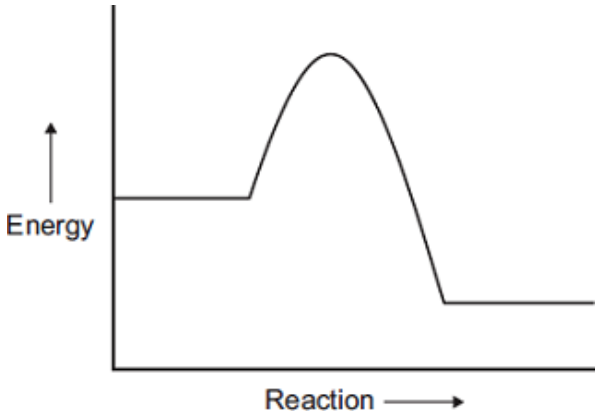
.....

.....

(2)

(e) An energy level diagram for the reaction between nitrogen and hydrogen is shown below.



(i) How does the energy level diagram show this reaction is exothermic?

.....

.....

(1)

(ii) In the Haber process iron is used as a catalyst.

Draw a line on the energy level diagram to show the effect of adding a catalyst.

(1)

(Total 8 marks)

Q5. Hydrogen could be the fuel used in all cars. One advantage is that when hydrogen reacts with oxygen only water is produced.

The chemical equation for this reaction is:

$$2\,H_2 \quad + \quad O_2 \longrightarrow \quad 2H_2O$$

This equation can be written showing the structural formulae.

$$2\ H—H \quad + \quad O=O \longrightarrow \quad 2\ H—O—H$$

(a) Use the bond energies in the table to calculate the energy change for this reaction.

Bond	Bond energy in kJ
H – H	436
O = O	498
O – H	464

.....

.....

.....

.....

Energy change = ... kJ

(3)

(b) Suggest why the bond energy of O = O is higher than the bond energies of both H – H and O – H.

.....

.....

(1)

(c) In terms of bond energies, explain why hydrogen can be used as a fuel

.....

.....

.....

(2)
(Total 6 marks)

Q6. Hydrogen peroxide decomposes to give water and oxygen.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

The reaction is *exothermic*.

(a) Explain, in terms of bond breaking and bond making, why the decomposition of hydrogen peroxide is *exothermic*.

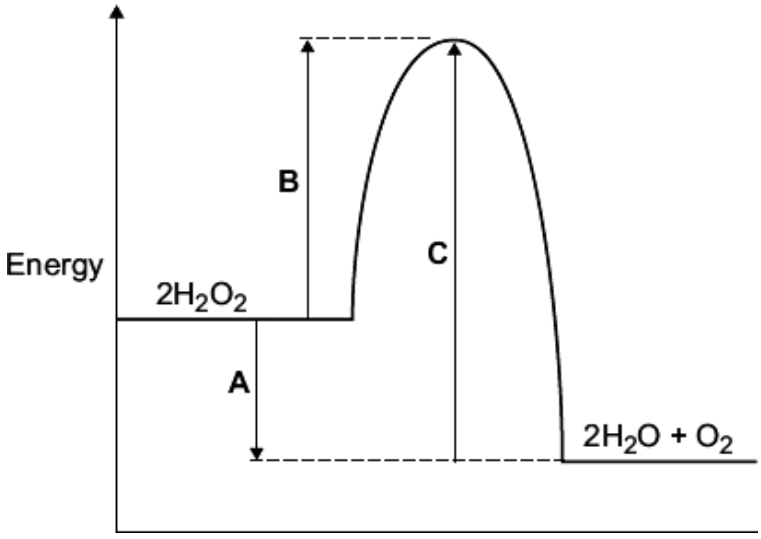
.....

.....

.....

(1)

(b) The energy level diagram for this reaction is shown below.



The energy changes, **A**, **B** and **C**, are shown on the diagram.

Use the diagram to help you answer these questions.

(i) How do you know that this reaction is *exothermic*?

.....

.....

.....

(1)

(ii) The decomposition of hydrogen peroxide is slow.
What does this suggest about energy change **B**?

.....

.....

.....

(1)

(iii) Hydrogen peroxide decomposes quickly when a small amount of manganese(IV) oxide is added.

Explain why.

.....

.....

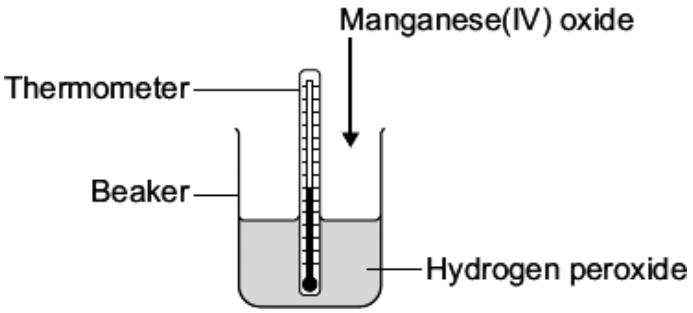
.....

.....

(2)

(c) A student did an experiment to find the amount of energy produced when hydrogen peroxide solution is decomposed using manganese(IV) oxide.

The apparatus the student used is shown in the diagram.



The student first measured the temperature of the hydrogen peroxide. Then the student added the manganese(IV) oxide and recorded the highest temperature.

The temperature rise was smaller than expected.

Suggest why.

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.....

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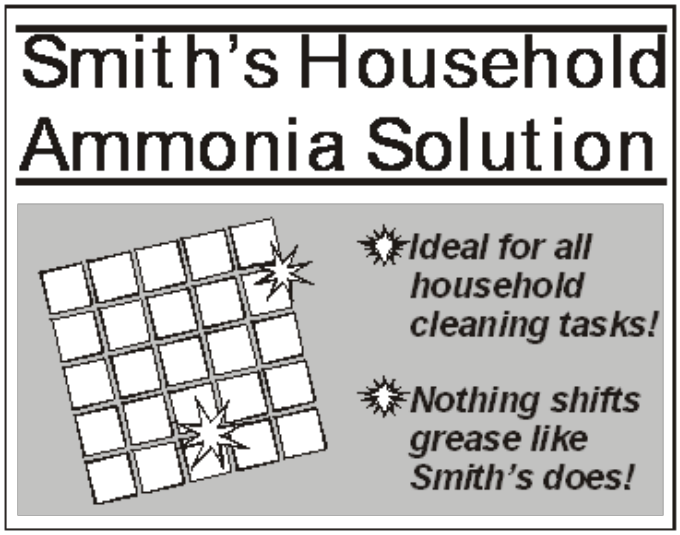
.....

.....

(2)
(Total 7 marks)

Q7. This label has been taken from a bottle of household ammonia solution.



Household ammonia is a dilute solution of ammonia in water. It is commonly used to remove grease from ovens and windows.

(a) The amount of ammonia in household ammonia can be found by titration.

25.0 cm^3 of household ammonia is placed in a conical flask. Describe how the volume of dilute nitric acid required to neutralise this amount of household ammonia can be found accurately by titration. Name any other apparatus and materials used.

To gain full marks you should write down your ideas in good English. Put them into a sensible order and use correct scientific words.

.....

.....

.....

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.....

.....

(4)

(b) In an experiment, it was found that 25.0 cm^3 of household ammonia was neutralised by 20.0 cm^3 of dilute nitric acid with a concentration of 0.25 moles per cubic decimetre.

The balanced symbol equation which represents this reaction is

$$NH_3(aq) + HNO_3(aq) \rightarrow NH_4NO_3(aq)$$

Calculate the concentration of the ammonia in this household ammonia in moles per cubic decimetre.

.....

.....

.....

.....

Concentration = ... moles per cubic decimetre

(2)

(c) The salt, ammonium nitrate, is formed in this reaction.

Describe, and give the result of, a chemical test which shows that ammonium nitrate contains ammonium ions.

.....

.....

.....

.....

(2)

(Total 8 marks)

M1. (a) lithium

allow Li^+ / Li

1

yellow

allow orange

1

(b) silver nitrate (solution)

*incorrect test = **0** marks*
ignore (nitric) acid
*do **not** allow other named acids*

1

white precipitate

1

(c) blue precipitate (with sodium hydroxide) indicates copper ions

allow Cu^{2+}

1

and white precipitate (with barium chloride) indicates sulfate ions

allow SO_4^{2-}

*accept compound X is copper sulfate / $CuSO_4$ for **1** mark*

1

but iron(II) ions produce a green precipitate (with sodium hydroxide)

1

[7]

M2. (a) (i) Na_2CO_3: HCl → gas / effervescence / bubbles (1)
CO_2 / carbon dioxide / turns lime water milky (1)

1

NaCl: $AgNO_3$ → white ppt (1)
silver chloride (1)

1

$NaNO_3$: Al + NaOH → pungent / sharp smell / choking gas (1)
NH_3 / ammonia / turns (red) litmus blue(1)

1

Na_2SO_4: $BaCl_2$ → white ppt (1)
barium sulfate (1)

1

*each correct test and one result = **1** mark*
***one** other result for any test = **1** mark this mark can only be awarded <u>once</u>*

(ii) all would give a yellow / yellow-orange (flame) / same coloured (flame) / same results

allow orange (flame) 1

or

they all contain sodium

1

(b) any **two** from:

ignore cost/errors

- fast / quick or comment about speed
  allow precise
- small amounts/sensitive
  allow can be left to run/continuous analysis
- accurate
- ease of automation
  accept operators do not need chemical skills
- sample not used up
- reliable / efficient

2

[7]

M3. (a) pipette / burette

1

(b) named indicator eg methyl orange / phenolphthalein

***not** universal*
*accept litmus but **not** litmus paper*

1

(c) $\frac{25 \times 0.4}{1000}$

2 for correct answer

1

= 0.01

1

(d) 1KOH ≡ 1 HCl

$\therefore$ 0.01 moles HCl in 35 cm^3

1

$\therefore \frac{0.01 \times 1000}{35} = 0.29$

2 for correct answer
0.3 = (1) (with correct working = (2))

1

[6]

M4. (a) air

1

(b) recycle

allow re-use

1

(unreacted) nitrogen and hydrogen

allow N_2 and H_2

1

(c) $N_2 + \mathbf{3}H_2 \rightarrow \mathbf{2}NH_3$

allow correct multiples

1

(d) *allow converse arguments*
ignore references to compromise

because a higher temperature would reduce (equilibrium) yield

allow higher temperature favours backward reaction

1

because a lower temperature would reduce rate

1

(e) (i) (energy of) reactants greater than (energy of) products

allow converse

allow (overall) energy decreases

allow energy required to break bonds is less than the energy released making bonds

1

(ii) line starting and finishing at same levels but with lower peak

1

[8]

M5. (a) reactants–
2 × H-H + 1 × O = O
= 1370 (kJ)

1

products–
4 × O-H = 1856 (kJ)

1

energy change = 486(kJ)

1

(b) O=O has a double (covalent) bond

or

O-H and H-H only have single (covalent) bonds

1

(c) hydrogen can be used as a fuel because when it reacts with oxygen more energy is released in bond making than used in bond breaking

1

therefore the reaction releases energy **or** the reaction is exothermic

1

[6]

M6. (a) energy released from making (new) bonds is greater than the energy needed to break (existing) bonds

accept the energy needed to break (existing) bonds is less than the energy released in making (new) bonds

*do **not** accept energy needed to make bonds*

1

(b) (i) energy / heat of products less than energy of reactants

accept products are lower than reactants

***or** reactants higher than products*

accept more energy / heat given out than taken in

***or** less energy / heat taken in than given out*

accept energy / heat is given out / lost (to the surroundings)

allow produce heat

ignore produce energy

accept ∆H is negative

***or** energy change / **A** is negative*

or B** is less than **C

1

(ii) **B** is (very) high / large

*it = **B***

*ignore energy change **C** is high*

1

(iii) *it = MnO_2*

(MnO_2) catalyst (is added)

accept it is a catalyst

or reaction catalysed (by MnO_2)

*do **not** accept MgO / magnesium oxide*

1

which lowers activation energy

accept provides alternative / lower energy pathway

or which lowers (energy change) **B**

if hydrogen peroxide is given as a catalyst instead of MnO_2

penalise once only in question

1

(c) any **two** from:

- (chemicals) not mixed / stirred
- heat / energy lost (from apparatus)
- (apparatus) not insulated **or** no lid
- low amount / mass / not enough MnO_2 **or** low concentration H_2O_2
- thermometer read incorrectly

  ignore other experimental error

2

[7]

M7. (a)

must *be a description of a titration no titration =* ***0*** *marks*

Quality of written communication

for correct sequencing of 2 of first 3 bullet points i.e. 1 + 2 ***or*** *2 + 3* ***or*** *1 + 3*

1

any **three** from:

- nitric acid in <u>burette</u>

  do ***not*** *accept biuret*
  can be inferred from 3rd point

- add nitric acid until <u>indicator</u> changes (colour)

  can be named acid-base indicator
  colour change does not have to be correct

- note (burette) volume used **or** final reading

- accuracy: e.g. repeat

  accept white tile ***or*** *dropwise near end* ***or*** *white background* ***or*** *swirling the flask* ***or*** *read meniscus at eye level*

3

(b) e.g. formula method:

$25 \times M_{NH3} = 0.25 \times 20$

1

$M_{NH3} = 0.2$

correct answer alone = ***2***

OR

moles NH_3 = moles HNO_3

$= \frac{20}{1000} \times 0.25 = 0.005$ moles (1)

concentration NH3

$= \frac{0.005 \times 1000}{25} = 0.2$ (1)

1

(c) sodium hydroxide **or** potassium hydroxide **or** lithium hydroxide **or** calcium hydroxide

ignore mention of alkali

1

ammonia produced

*accept gas produced turns (damp) (red) litmus blue (not blue litmus) **or** <u>alkaline</u> gas produced*

any suitable named indicator e.g. UI with consequential marking
white fumes / smoke with (concentrated) HCl

*do **not** accept white gas wrong test = **0** marks*

1

[8]