Name	Date started	Target end date

GCE AS / A LEVEL — CHEMISTRY UNIT 1 QUESTION PACK

1091-01 (Legacy CH1) · New spec Unit 1 Topic 8 · AS unit, first sat 2016, 80 marks, 1h 30min paper

REVISE
.wales

CHEMISTRY — UNIT 1 · EQUILIBRIA & LE CHATELIER

Topic 1.7 — Dynamic equilibrium, Le Chatelier's principle and the equilibrium constant Kc

Recognising dynamic equilibrium, predicting the effect of changes in temperature, pressure and concentration using Le Chatelier's principle, and applying Kc qualitatively to industrial systems like the Haber process.

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~4 h

Derived from the legacy CH1 paper's pace of ~1.1 min/mark, padded for long-prose answers (150 marks over 14 questions).

*You are advised to **not** attempt to complete all of this in one sitting.*

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC CH1 papers (2008 modular spec, Jan 2009 – Jun 2016) that maps onto the new-spec AS Unit 1 Topic 1.7.

Questions are ordered by source paper date.

INSTRUCTIONS

Use black ink or black ball-point pen. Show all working — quality of written communication will affect marks. A calculator is allowed. You may need the WJEC Periodic Table / Data Booklet.

For Examiner's use only

Q	Source	Max	Mark
1	Jan 09 Q5	11	
2	Jun 09 Q6	15	
3	Jan 10 Q6	2	
4	Jan 10 Q8	17	
5	Jun 10 Q7	14	
6	Jun 11 Q9	7	
7	Jan 12 Q3	2	

Q	Source	Max	Mark
8	Jan 12 Q7	19	
9	Jun 12 Q9	16	
10	Jan 13 Q5	2	
11	Jun 13 Q12	15	
12	Jan 14 Q3	4	
13	Jun 14 Q10	13	
14	Jun 16 Q9	13	
Total		**150**	

Equilibria & Le Chatelier — what the new spec asks

WJEC GCE AS / A Level Chemistry (from 2015) · Unit 1: The Language of Chemistry, Structure of Matter & Simple Reactions · Topic 1.7.

Dynamic equilibrium

- Forward & reverse reactions occur simultaneously.
- $Rate_{forward}$ = $rate_{reverse}$.
- Concentrations stay constant; reaction not stopped.
- Only reached in a closed system.

Le Chatelier's principle

- If a system at equilibrium is disturbed, it shifts to oppose the change.
- ↑ [reactant] or ↓ [product]: shift right.
- ↑ pressure: shift to side with fewer gas moles.
- ↑ temperature: shift in endothermic direction.

Catalysts at equilibrium

- Catalysts speed up both directions equally.
- Position of equilibrium unchanged.
- Time taken to reach equilibrium decreases.

Kc — qualitative

- K_c = [products]^x / [reactants]^y.
- Only temperature affects K_c.
- Larger K_c ⇒ equilibrium lies further right.

Industrial examples

- Haber: $N_2 + 3H_2 \leftrightarrow 2NH_3$ — high P, moderate T (compromise).
- Contact: $2SO_2 + O_2 \leftrightarrow 2SO_3$ — V_2O_5 catalyst.
- Ethanol hydration: $CH_2{=}CH_2 + H_2O \leftrightarrow C_2H_5OH$.

Crib sheet »

Equilibria & Le Chatelier in one page

Quick-reference notes — revisit before each question.

Equilibrium signals

Closed system; constant T.

Concentrations no longer changing.

Both directions still occur.

Le Chatelier — conc

↑ reactant: shifts right.

Remove product: shifts right.

Inert solid: no effect.

Le Chatelier — pressure

↑ pressure shifts to side with fewer gas moles.

No effect if equal moles each side.

Le Chatelier — temperature

↑ T shifts in endothermic direction (ΔH positive).

↓ T shifts toward exothermic side.

Only T changes K_c.

Catalysts

No effect on position.

Reach equilibrium faster.

K_c unchanged.

Industrial compromise

Haber: 450°C, 200 atm, Fe catalyst.

Contact: 450°C, 1-2 atm, V_2O_5.

High T speeds rate but reduces yield (exothermic).

SECTION B

Answer all the questions in the spaces provided.

5. (a) Polluting gases such as sulfur dioxide, SO_2, produced from power stations, can cause the acidification of lakes far from the source of the pollution. At a lake-water pH of 6·0, water snails start to die and when the pH reaches 5·5, fish also begin to die.

State how you would explain to the general public how the pH scale is used to describe levels of acidity. [2]

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.....

(b) An equation for the reaction of sulfur dioxide with water is shown below.

$$SO_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + HSO_3^-(aq)$$

(i) Use the equation to explain why sulfur dioxide is described as an acidic oxide. [1]

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.....

(ii) A solution of sulfur dioxide in water reaches a position of dynamic equilibrium. Explain what is meant by the term dynamic equilibrium. [1]

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.....

(iii) Use Le Chatelier's principle to explain how the concentration of hydrogen ions, $H^+(aq)$, would change if more sulfur dioxide were dissolved in a solution that had reached dynamic equilibrium. [2]

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(c) One method of removing sulfur dioxide from power station emissions is to react the flue gases with moist calcium carbonate (limestone), giving hydrated calcium sulfate (gypsum) and carbon dioxide.

$$2SO_2 + 2CaCO_3 + 4H_2O + O_2 \longrightarrow 2CaSO_4.2H_2O + 2CO_2$$

One advantage of this process is that the gypsum can be used for the production of plaster.
State two disadvantages of this method of sulfur dioxide removal, apart from cost. [2]

Disadvantage 1 .....

.....

Disadvantage 2 .....

.....

(d) Some students measured the concentration of sulfur dioxide in the air.
They pumped air at a rate of 20 dm^3 per hour for 5 days through a suitable solution that absorbed the sulfur dioxide present.
The resulting solution was then treated to give 0·0047 g of barium sulfate, $BaSO_4$.
You should assume that 1 mole of sulfur dioxide gives 1 mole of barium sulfate.

(i) Calculate the total volume of air passed through the solution in 5 days. [1]

.....

..... dm^3

(ii) Calculate the relative molecular mass of barium sulfate. [1]

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.....

(iii) Use your answer to (ii) to calculate the number of moles of barium sulfate present. [1]

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(iv) State the number of moles of sulfur dioxide present in the sampled air. [1]

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(v) Calculate the volume of sulfur dioxide present in the sampled air. [1]
[One mole of sulfur dioxide has a volume of 24·0 dm^3 under these conditions.]

.....

..... dm^3

(vi) Calculate the percentage by volume of sulfur dioxide in the sampled air. [1]

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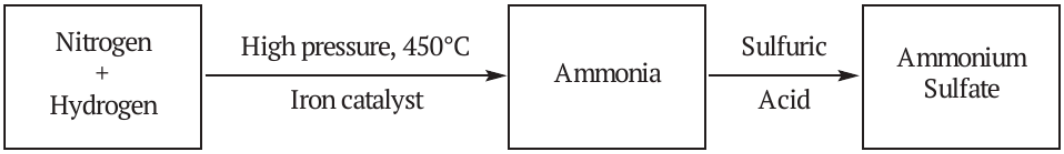
.....

Total [14]

6. (a) Ammonia, a very important industrial product, is produced by the Haber process. Ammonia can be converted to ammonium sulfate, $(NH_4)_2SO_4$, a common fertiliser, by reacting it with sulfuric acid, H_2SO_4.



The Haber process can be represented by the following equation.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H^{\ominus} = -92 \text{ kJ mol}^{-1}$$

(i) Explain how a catalyst speeds up a reaction. [2]

(ii) What type of catalyst is iron in the above process? [1]

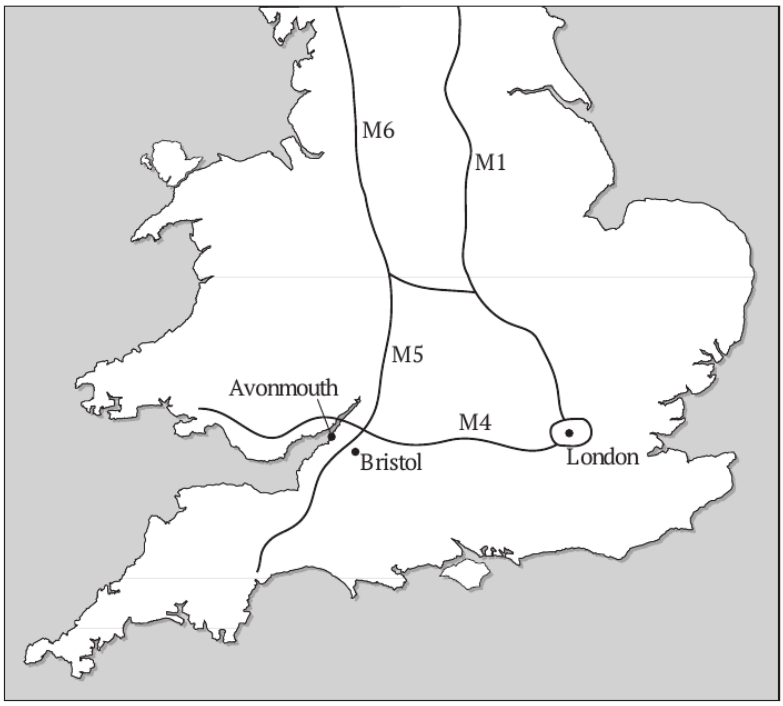
(iii) For the equilibrium reaction, explain why

I. there has been much research to find a better catalyst, [2]

II. a high pressure is used, [2]

III. ammonia is removed from the equilibrium mixture as it forms. [2]

(iv) In Britain, an ammonia factory is sited at Avonmouth on the banks of the River Severn near Bristol.



Give two reasons why this site was chosen. [2]

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(b) (i) Write an equation for the acid-base reaction of ammonia with sulfuric acid. [1]

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(ii) Explain why ammonia behaves as a base in this reaction. [1]

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(iii) Farmers use ammonium sulfate as a fertiliser.

Calculate the percentage by mass of nitrogen in ammonium sulfate, $(NH_4)_2SO_4$. [2]

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Total [15]

Examiner only

5. Sketch a diagram to show the shape of a p-orbital. [1]

6. *(a)* Explain the term *dynamic equilibrium* for a chemical system. [1]

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(b) Explain how you would tell, from the properties of the system, that equilibrium has been reached. [1]

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.....

Section A Total [10]

Examiner only

8. Because of the link to global warming, much effort is being devoted to investigating how emissions of carbon dioxide, CO_2, into the atmosphere by power stations burning fossil fuels can be reduced or eliminated.

(a) One area of investigation is the removal of CO_2 by sodium carbonate. Three possible reactions are:

$Na_2CO_3(s) + CO_2(g) + H_2O(g) \rightleftharpoons 2NaHCO_3(s)$ **Reaction 1**

$3Na_2CO_3(s) + CO_2(g) + 5H_2O(g) \rightleftharpoons 2Na_2CO_3.NaHCO_3.2H_2O(s)$ **Reaction 2**

$5Na_2CO_3(s) + 3CO_2(g) + 3H_2O(g) \rightleftharpoons 2Na_2CO_3.3NaHCO_3(s)$ (Wegscheider's Salt) **Reaction 3**

(i) Giving a reason, determine from the equations which of the three reactions uses sodium carbonate, $Na_2CO_3(s)$, most effectively to absorb $CO_2(g)$. [2]
QWC [1]

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(ii) State Le Chatelier's Principle. [1]

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(iii) Giving your reasons, use Le Chatelier's Principle to determine whether $CO_2(g)$ removal will be more efficient at high gas pressure or low gas pressure. [2]

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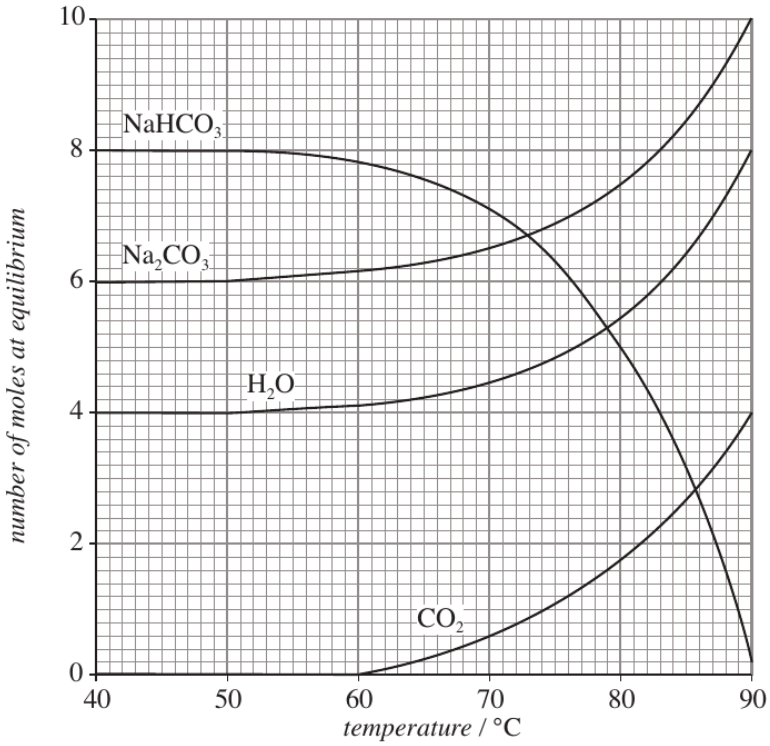
Examiner only

(b) For one industrial system using **Reaction 1**

$$Na_2CO_3(s) + CO_2(g) + H_2O(g) \rightleftharpoons 2NaHCO_3(s)$$

the amount of each species present at equilibrium was measured over a range of temperatures. The graph below shows the results.



(i) Giving your reasoning, determine from the graph whether the forward reaction in **Reaction 1** is exothermic or endothermic. [2]

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(ii) After the removal of $CO_2(g)$, the solid $NaHCO_3$ residue is taken away and recycled to regenerate sodium carbonate, $Na_2CO_3(s)$.

I By using the graph, or otherwise, determine how sodium carbonate, $Na_2CO_3(s)$, can be regenerated from the $NaHCO_3$ residue. [1]

.....

II State **one** problem associated with the regeneration of sodium carbonate, $Na_2CO_3(s)$, by the method you have given. [1]

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Examiner only

(c) Another area of investigation is the use of a new type of plastic membrane, structured by means of nanotechnology, to catch carbon dioxide gas whilst allowing other waste gases to pass freely through.

If 1000 dm^3 of waste gas at 25 °C yielded 275 g of carbon dioxide, separated by a plastic membrane, calculate:

(i) the number of moles of carbon dioxide in the 275 g separated by the membrane; [2]

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.....

(ii) the volume of carbon dioxide separated at 25 °C; [1]

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.....

[One mole of gas has a volume of 24.0 dm^3 at 25 °C and 1 atm pressure]

(iii) the percentage by volume of carbon dioxide in the waste gas. [1]

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(d) Carbon dioxide, CO_2 is an *acid gas*.

(i) Define the term *acid*. [1]

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(ii) By considering its interaction with water, explain how carbon dioxide can behave as an acid. [1]

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(iii) Though the pH of pure water is 7, explain why naturally-occurring water in contact with air has a pH of less than 7. [1]

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Total [17]

Examiner only

SECTION B

Answer **all** *questions in the spaces provided.*

7. Ammonia, NH_3, is produced from nitrogen and hydrogen.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(a) Typically, this process is carried out at a temperature of 450 °C, at a pressure of 250 atmospheres and in the presence of an iron catalyst. The yield is around 15%.

(i) If this reaction were carried out using a reduced pressure of 50 atmospheres, the process would be safer because of the lower pressure used.

State **one** disadvantage of using this lower pressure. [1]

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(ii) In the actual process some of the ammonia is removed as the reaction proceeds.

State and explain what effect this removal has on the position of equilibrium. [2]

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(iii) How would the equilibrium yield be affected if the reaction were run without using the catalyst? [1]

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(b) Some of the ammonia is reacted with sulfuric acid to produce the fertiliser ammonium sulfate.

$$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

(i) State the molar masses of

ammonia ..... g ammonium sulfate ..... g [1]

(ii) Calculate the maximum mass of ammonium sulfate, in tonnes, that can be made from 17.03 tonnes of ammonia. [3]

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Examiner only

(c) A member of the public read in an article that the pH of an ammonium sulfate solution was 6. He asked you to explain what was meant by the pH scale.
What would be your reply? [2]

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(d) Ammonium nitrate, NH_4NO_3, is also used as a fertiliser. However, in the presence of certain impurities, it can explode very violently. This explosive reaction gives nitrogen, oxygen and steam.

$$NH_4NO_3(s) \longrightarrow N_2(g) + 2H_2O(g) + \tfrac{1}{2}O_2(g) \quad \Delta H = -296 \text{ kJ mol}^{-1}$$

M_r 80

Some years ago 400 tonnes (4×10^8 g) of ammonium nitrate, stored in a ship in a harbour, exploded, causing extensive damage.

Calculate the energy produced in this explosion, in kJ. [2]

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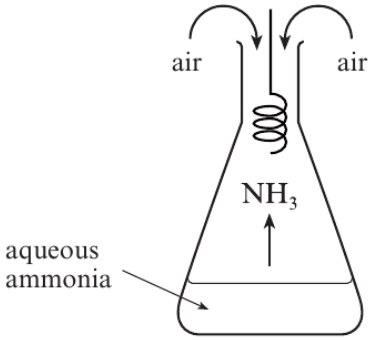
Examiner only

(e) Ammonia gas can be oxidised in air in the presence of a platinum catalyst. One method of showing this is to suspend a red-hot spiral of platinum wire in the neck of a flask containing ammonia gas and air. The platinum wire continues to glow red-hot as the ammonia is oxidised.



(i) Use the information given to explain how this experiment shows that the oxidation of ammonia is an exothermic reaction. [1]

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(ii) The platinum wire is acting as a heterogeneous catalyst in this reaction. Explain what is meant by the term 'heterogenous'. [1]

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Total [14]

1091 01 07

Examiner only

9. This question is about equilibria in seawater and the effect of carbon dioxide from burning fuels on the acidity of seawater. It involves the use of Le Chatelier's principle.

(a) State *Le Chatelier's principle*. [1]

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.....

(b) Describe in simple terms what is meant by pH. [1]

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(c) About half of the carbon dioxide formed by burning fossil fuels dissolves in the oceans. The equilibrium may be written simply as:

$$CO_2 + H_2O \rightleftharpoons H^+ + HCO_3^-$$

(i) State, giving a reason in both cases, the effect that increasing carbon dioxide concentrations have on

I the ocean's acidity, [1]

.....

.....

II the pH of seawater. [1]

.....

.....

(ii) Another important equilibrium in the ocean is that between hydrogencarbonate and carbonate ions.

$$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$$

State, giving a reason, the effect of increasing acidity on the amount of carbonate present. [1]

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(iii) Many animals in the ocean make shells of calcium carbonate using the equilibrium:

$$Ca^{2+}(aq) + CO_3^{2-}(aq) \rightleftharpoons CaCO_3(s)$$

Using your answer to parts (i) and (ii), state and explain the effect of increasing acidity on their ability to make shells. [1]

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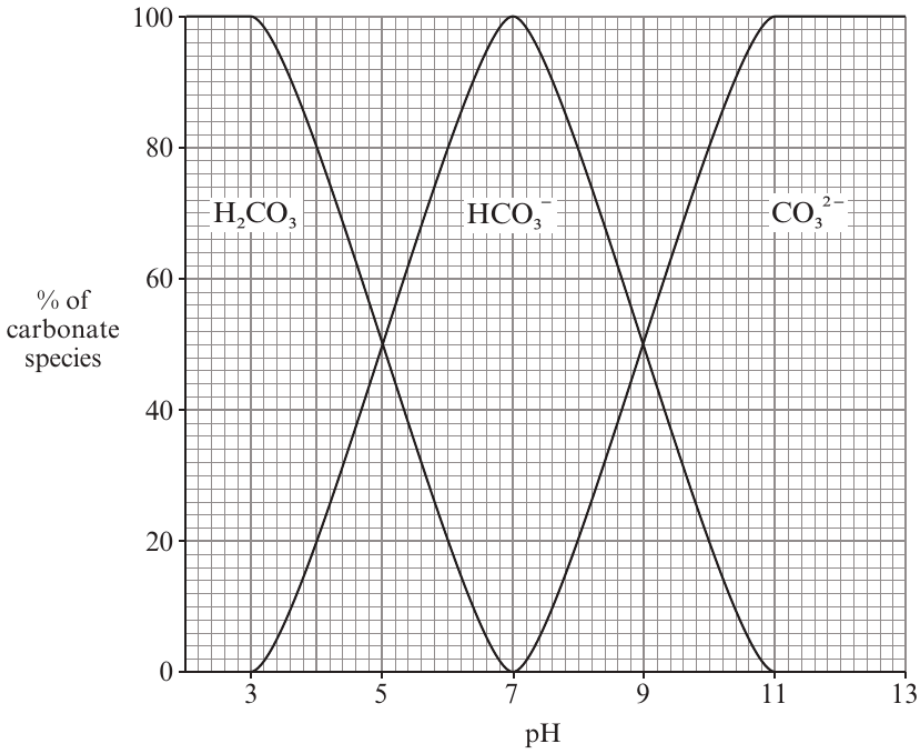
Examiner only

(d) The plot below shows how the proportions of the three carbonate species in the ocean change with pH.



Using the graph, find the pH of the ocean if it contains 90% hydrogencarbonate ions and 10% carbonate ions. [1]

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(e) A study of a model ocean included measuring a hydrogencarbonate concentration by titrating with acid.
25.00 cm^3 of hydrogencarbonate solution was neutralised by 19.60 cm^3 of hydrochloric acid of concentration 0.095 mol dm^{-3}, the equation being:

$$HCO_3^- + H^+ \longrightarrow H_2CO_3$$

Calculate the concentration of hydrogencarbonate ions in the solution. [2]

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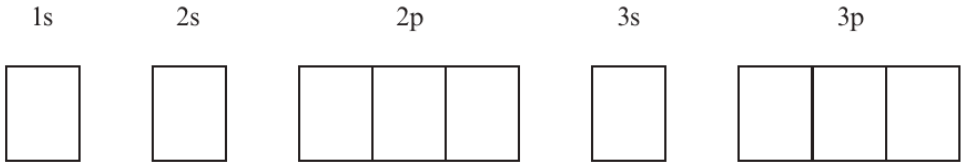
Total [9]

Examiner only

SECTION A

Answer **all** *questions in the spaces provided.*

1. By inserting arrows to represent electrons, complete the boxes below to show the electronic configuration of a sulfur atom. [1]



2. State the number of protons present in an aluminium ion, Al^{3+}. [1]

A 10
B 13
C 14
D 16

.....

3. Weak *acids* establish a *dynamic equilibrium* when dissolved in water.
Give brief explanations of what is meant by the following terms. [2]

Acid .....

.....

Dynamic equilibrium .....

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Examiner only

SECTION B

Answer **all** *questions in the spaces provided.*

7. Hydrocarbons play an important role in our life today, both as fuels and as raw materials for the synthesis of a wide range of materials. Most hydrocarbons are isolated from crude oil, however there is increasing interest in alternative methods of obtaining these molecules.

(a) One route to the production of hydrocarbons is the Fischer-Tropsch process, which uses hydrogen and carbon monoxide as starting materials to produce a range of molecules. The equation below shows the production of pentane, C_5H_{12}, by this route.

$$11H_2(g) + 5CO(g) \longrightarrow C_5H_{12}(l) + 5H_2O(l) \qquad \Delta H^{\ominus} = -1049\,kJ\,mol^{-1}$$

The enthalpies of formation of some of these substances are given in the table below.

Substance	Standard enthalpy of formation, $\Delta H_f^{\ominus}$ / kJ mol^{-1}
Hydrogen, $H_2(g)$	0
Carbon monoxide, CO(g)	–111
Water, $H_2O(l)$	–286

(i) State the temperature and pressure used as standard conditions. Give units for each. [2]

Temperature ..... *Pressure* .....

(ii) State why the standard enthalpy of formation for hydrogen gas is 0 kJ mol^{-1}. [1]

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(iii) Use the values given to calculate the standard enthalpy of formation for pentane, $C_5H_{12}(l)$, in kJ mol^{-1}. [3]

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Examiner only

(b) The Fischer-Tropsch process uses a heterogeneous catalyst containing iron.

(i) State what is meant by the term *heterogeneous* in this context. [1]

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.....

(ii) Explain how a catalyst increases the rate of a chemical reaction. [2]

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(iii) Chemical manufacturers consider catalysts to be a key part of production methods that have the minimum possible effect on the environment ('Green Chemistry'). Give **one** reason why the use of catalysts reduces the effect on the environment.[1]

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(iv) An alternative method of increasing the rate of a chemical reaction is to increase the temperature. Explain why temperature affects the rate of a chemical reaction. [3]
QWC [1]

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Examiner only

(c) One method of producing the hydrogen gas required for the Fischer-Tropsch process is to use the reversible reaction below.

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g) \qquad \Delta H = -42\,kJ\,mol^{-1}$$

(i) State and explain the effect, if any, of increasing pressure on the yield of hydrogen gas produced at equilibrium. [2]

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.....

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(ii) State and explain the effect, if any, of increasing temperature on the yield of hydrogen gas produced at equilibrium. [2]

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.....

(iii) This reaction uses a catalyst based on iron oxide. State the effect of using a catalyst on the position of equilibrium. [1]

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Total [19]

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Examiner only

9. Ethanol is an important industrial chemical and can be made by the direct hydration of ethene using a phosphoric acid catalyst.

$$CH_2{=}CH_2(g) + H_2O(g) \rightleftharpoons CH_3CH_2OH(g) \quad \Delta H = -46\,kJ\,mol^{-1}$$

(a) State, giving your reasons, the general conditions of temperature and pressure required to give a high equilibrium yield of ethanol in this process. [4]

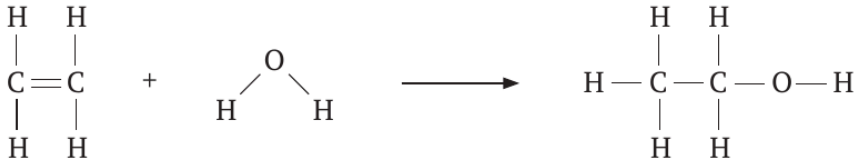
QWC [1]

(b) Using the standard enthalpy change for the reaction above and the standard enthalpy changes of formation ($\Delta H_f^{\ominus}$) given in the table below, calculate the standard enthalpy change of formation of gaseous ethanol. [3]

Compound	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$CH_2{=}CH_2(g)$	52.3
$H_2O(g)$	–242

Examiner only

(c) Another way of calculating the enthalpy change of a reaction is by using average bond enthalpies. Use the values in the table below to calculate the enthalpy change for the direct hydration of ethene. [3]



Bond	Average bond enthalpy / kJ mol^{-1}
C — C	348
C = C	612
C — H	412
C — O	360
O — H	463

(d) (i) Give a reason why the calculated value in *(c)* is different to the actual value, –46 kJ mol^{-1}. [1]

(ii) Explain whether your answer to part (i) supports the use of average bond enthalpies to calculate the energy change for a reaction. [1]

Examiner only

(e) Phosphoric acid is an example of a heterogeneous catalyst.
Explain the term *heterogeneous* in this context. [1]

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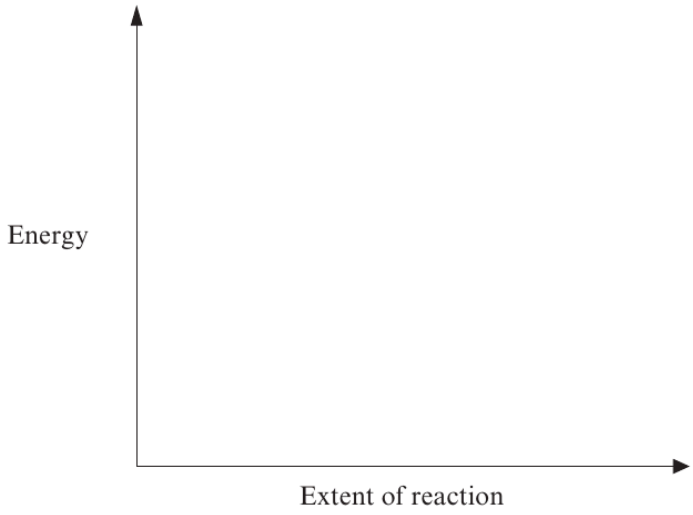
(f) (i) Sketch on the axes below the energy profile for an exothermic reaction. [1]

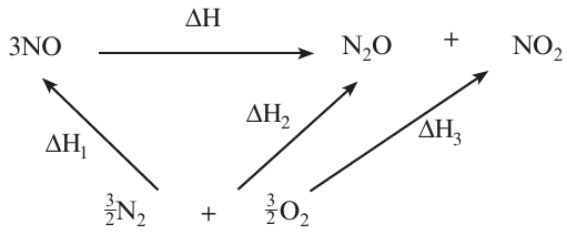


(ii) On the same axes, sketch and label the energy profile if the same reaction is carried out using a catalyst. [1]

Total [16]

Examiner only

4. The energy cycle for a decomposition of nitrogen(II) oxide is shown below.



(a) Complete the equation to show ΔH in terms of ΔH_1, ΔH_2 and ΔH_3. [1]

ΔH = ...

(b) Write the chemical equation for the standard molar enthalpy change of formation of gaseous nitrogen(II) oxide, NO. [1]

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5. Carbon oxide sulfide, COS, is obtained by heating together carbon monoxide and gaseous sulfur.

$$2CO(g) + S_2(g) \rightleftharpoons 2COS(g)$$

State and explain any change that occurs when more carbon monoxide is added to the equilibrium mixture. [2]

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Examiner only

12. *(a)* The combustion of fossil fuels containing sulfur impurities is known to cause acid rain. This acid rain can cause the erosion of marble statues as the calcium carbonate in them reacts with the acid in the rain.

Give **one** other problem caused by acid rain. [1]

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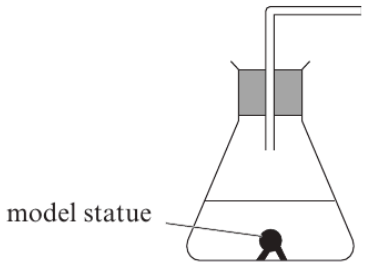
.....

(b) A chemist is developing coatings for marble that will slow down the rate of their erosion by acid rain. To compare different coatings he uses small model statues, all of which are the same size and shape as each other. He proposes to measure the rate of reaction by adding acid and measuring the volume of gas given off at set time intervals.

(i) Complete the diagram to show the apparatus that could be used to perform this experiment. [1]



(ii) Explain why it is important that the model statues are the same size and shape as each other. [1]

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(iii) State **two** other factors he will need to keep constant if he is to collect valid data. [2]

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Examiner only

(c) One gas that causes acid rain is sulfur dioxide. This gas is used to produce sulfur trioxide in the Contact Process. The reaction occurring is shown in the following equation.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(i) State and explain the effect of increasing pressure on the equilibrium yield of sulfur trioxide. [2]

(ii) When the temperature is increased the rate at which equilibrium is reached is increased and the yield of sulfur trioxide is decreased.

I State whether this reaction is endothermic, exothermic or neither, giving a reason for your answer. [2]

Examiner only

II Explain why increasing the temperature leads to an increase in the rate of reaction. [3]

III To increase the rate of a reaction, a catalyst can be used. Give a **different** catalysed reaction and name the catalyst for this reaction. [1]

Examiner only

(d) Ethanoic acid, CH_3COOH, is one of the most familiar compounds used as a flavouring and preservative for food. Originally ethanoic acid was produced by oxidation of ethanol by bacteria in the presence of air (route **A** below). Today there are many other possible routes and three of these are shown as routes **B**, **C** and **D** below.

Route	Carbon-containing starting materials	Conditions	Overall equation	Atom economy
A	ethanol		$C_2H_5OH + O_2 \rightarrow CH_3COOH + H_2O$	76.9%
B	methanol, carbon monoxide	150 °C, 30 atm	$CH_3OH + CO \rightleftharpoons CH_3COOH$	100.0%
C	butane	150 °C, 55 atm	$2C_4H_{10} + 5O_2 \rightarrow 4CH_3COOH + 2H_2O$	87.0%
D	sugars		$C_6H_{12}O_6 \rightarrow 3CH_3COOH$	

(i) State the atom economy of route **D** for production of ethanoic acid. [1]

.....

(ii) Route **B** is the route most commonly used for producing ethanoic acid today for both financial and *Green Chemistry* reasons. Apply the principles of *Green Chemistry* to the information above to give **two** reasons why route **B** is favoured over route **C**. [2]

1. .....

.....

2. .....

.....

(iii) Route **B** uses a homogeneous catalyst. State what effect the catalyst will have on the position of this equilibrium. [1]

.....

.....

Total [17]

Section B Total [70]

Examiner only

SECTION A

Answer **all** *questions in the spaces provided.*

1. An element, X, has an atomic number of 9 and forms an ion X^-. State which **one** of the following shows the numbers of protons and electrons in this **ion**. [1]

	protons	electrons
A	8	9
B	9	8
C	9	9
D	9	10

2. State which **one** of the following shows the mass of aluminium that contains the same number of atoms as there are molecules in 11.0 g of carbon dioxide, CO_2. [1]

A 6.75 g

B 13.5 g

C 27.0 g

D 54.0 g

3. The isotope ^{32}P is radioactive. It decays by β-emission and has a half-life of 14 days.

(a) State what is meant by *β-emission*. [1]

.....

.....

(b) Give the mass number **and** symbol of the atom formed by the loss of one β-particle from an atom of ^{32}P. [1]

.....

(c) State what is meant by the term *half-life*. [1]

.....

.....

(d) Calculate how long it will take a sample of ^{32}P to decay from 8 g to 1 g. [1]

Time taken = ... days

Examiner only

10. The decomposition of dinitrogen(IV) oxide into nitrogen(IV) oxide is a reversible reaction that establishes a dynamic equilibrium.

$$\underset{\text{pale yellow}}{N_2O_4(g)} \rightleftharpoons \underset{\text{dark brown}}{2NO_2(g)} \qquad \Delta H = +57 \text{ kJ mol}^{-1}$$

(a) State the meaning of the term *dynamic equilibrium*. [1]

.....

.....

(b) The conditions applied to an equilibrium mixture of dinitrogen(IV) oxide and nitrogen(IV) oxide were changed. For each of the following, state what was **seen** and explain any change that occurred. [5]

Temperature increased

.....

.....

.....

Pressure increased

.....

.....

.....

A catalyst was added

.....

.....

Examiner only

(c) Hydrazine, N_2H_4, is an unstable liquid that decomposes according to the following equation.

$$N_2H_4(l) \longrightarrow N_2(g) + 2H_2(g)$$

(i) Calculate the volume of gas that could be obtained from 14 kg of hydrazine. Assume that the volume of 1 mol of gas is 24.0 dm^3. [3]

Volume of gas = ... dm^3

(ii) One use of hydrazine is as a fuel in rockets. Apart from any energy changes, state **one** feature of this reaction that suggests it would be useful in rocket propulsion. [1]

.....

.....

(d) Nitrogen (IV) oxide reacts with water.

$$H_2O + 2NO_2 \longrightarrow HNO_2 + HNO_3$$

Both nitric(III) acid, HNO_2, and nitric(V) acid, HNO_3, are described as being acids.

(i) Define an *acid*. [1]

.....

(ii) Complete the equation to show nitric(III) acid behaving as an acid. [1]

$$HNO_2 + H_2O \longrightarrow$$

(iii) When concentrated nitric(V) acid is mixed with concentrated sulfuric acid the reaction shown below occurs.

$$HNO_3 + H_2SO_4 \longrightarrow H_2NO_3^+ + HSO_4^-$$

Explain this reaction in terms of acid-base behaviour. [2]

.....

.....

Total [14]

Examiner only

9. *(a)* Methanol, CH_3OH, is made from a mixture that contains carbon monoxide and hydrogen.

(i) Use the table of average bond enthalpies to calculate the enthalpy change for this reaction. [2]

Bond	Bond enthalpy / kJ mol^{-1}
C — O	336
C — H	413
H — H	436
O — H	464
C ⩵ O in carbon monoxide	1077

Enthalpy change = ... kJ mol^{-1}

(ii) State why the calculated value for the enthalpy change of reaction may not be the same as the literature value. [1]

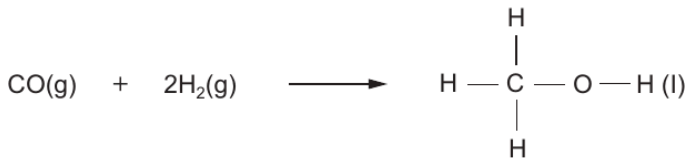
.....

.....

.....

Examiner only

(iii) The literature value of the enthalpy change for the reaction



is more exothermic than the literature value for the reaction shown opposite.

State why these two values are different, explaining your answer. [1]

(iv) The reaction to make methanol is in dynamic equilibrium.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

I. State what is meant by the term *dynamic equilibrium*. [1]

II. Use the equation above and your answer to (i) to suggest and explain the conditions of temperature and pressure that will give the greatest yield of methanol. [2]

Turn over.

Examiner only

(b) The equation for the reaction that represents the enthalpy change of combustion of methanol, ΔH_c , is shown below.

$$CH_3OH(l) + 1\tfrac{1}{2}O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$$

(i) Estimate the enthalpy change of combustion of methanol by using the following table, explaining how you obtained your answer. [2]

Name of alcohol	Number of carbon atoms in the alcohol	Enthalpy change of combustion / kJ mol^{-1}
butan-1-ol	4	−2678
pentan-1-ol	5	−3331
hexan-1-ol	6	−3984

.....

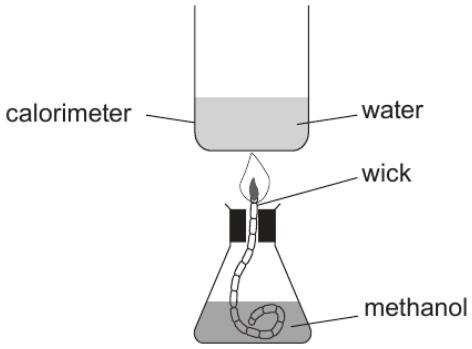
.....

.....

Enthalpy change of combustion = ... kJ mol^{-1}

Examiner only

(ii) Enthalpy changes of combustion can be measured directly. A student used the apparatus below to obtain the value for methanol.



The result obtained by this method is often lower than the accepted value.

Suggest **one** way in which the apparatus could be modified in order to obtain a result closer to the expected value, giving a reason for your answer. [2]

.....

.....

.....

(iii) In another experiment the enthalpy change of combustion of methanol was measured and found to be −680 kJ mol^{-1}.

Calculate the mass of methanol burned in this experiment if the energy released by burning the methanol was 18.7 kJ. [2]

Mass of methanol = ... g

Total [13]

END OF QUESTION PACK

14 questions · 150 marks · ~4 h
Source: WJEC CH1 (2008 modular spec, Jan 2009 – Jun 2016)
Curated for WJEC Chemistry 2015 spec AS Unit 1 — Topic 8 (1.7)