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Examiners' report

CHEMISTRY B (SALTERS)

H033

For first teaching in 2015

H033/01 Summer 2022 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers is also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Advance Information for Summer 2022 assessments

To support student revision, advance information was published about the focus of exams for Summer 2022 assessments. Advance information was available for most GCSE, AS and A Level subjects, Core Maths, FSMQ, and Cambridge Nationals Information Technologies. You can find more information on our website.

Paper 1 series overview

This synoptic paper targets all three assessment objectives requiring candidates to:

- demonstrate and apply knowledge and understanding of scientific ideas, processes, techniques and procedures in theoretical and practical contexts
- handle qualitative and quantitative data
- analyse, interpret and evaluate scientific information to make judgements and reach conclusions
- show an ability to develop practical procedures.

To do well, candidates needed to demonstrate a broad knowledge and understanding of inorganic, organic and physical chemistry and be able to carry out multi-step calculations.

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
• read the questions carefully and responded appropriately • gave concise answers to long-answer questions • showed careful working in calculations.	• left many parts unanswered instead of writing something relevant • drew unclear diagrams • set out calculations unclearly.

Section A overview

Most candidates attained reasonable marks on this section. Good exam technique dictates that no question should be left unanswered. If they wish to change an answer, candidates should be encouraged to cross out their original answer and write the new letter to the right of the answer box. Writing over the original answer often makes answers hard to decipher.

Question 1

1 Which ion has the same electron configuration as Ca^{2+}?

A Al^{3+}

B Br^{-}

C K^{+}

D Mg^{2+}

Your answer ☐ **[1]**

Most candidates scored here, showing a good understanding of the electron configurations of ions and selecting the correct answer, C. The most common wrong answer was D – presumably candidates who selected this answer only considered the outer electrons.

Question 2

2 Sodium has a lower melting point than magnesium.

What is a reason for this?

A Magnesium has more delocalised electrons per atom.

B Magnesium is more ionic.

C Melting points decrease across Period 3.

D Sodium has a covalent structure.

Your answer ☐ **[1]**

A majority of candidates selected the correct answer, A, showing an understanding of the trends in Period 3. A few candidates selected C.

Question 3

3 Which row is correct for the properties of the solids shown?

	Solid	Melting point	Electrical conductivity
A	graphite	high	poor
B	iodine	high	poor
C	iron	low	good
D	sodium chloride	high	poor

Your answer ☐ **[1]**

A majority of candidates selected the correct answer, D. The most common wrong answer was B.

Question 4

4 Which compound is a saturated aliphatic hydrocarbon?

A benzene

B cyclohexane

C cyclohexene

D hexene

Your answer ☐ **[1]**

Most candidates selected the correct answer, B, showing an understanding of the terms involved. A was the most common wrong answer.

Question 5

5 Which reaction has the **largest** atom economy for the formation of the organic product?

A $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$

B $C_2H_5Br + Br_2 \rightarrow C_2H_4Br_2 + HBr$

C $C_6H_6 + Br_2 \rightarrow C_6H_5Br + HBr$

D $C_2H_6 + Br_2 \rightarrow C_2H_5Br + HBr$

Your answer ☐ **[1]**

Most candidates correctly selected A, realising that the atom economy is always 100% for a reaction with only one product. The most common wrong answer was B.

Question 6

6 What is a correct property of hydrogen iodide gas?

A It has high thermal stability.

B It is neutral in solution.

C It is unreactive with ammonia.

D It reduces sulfuric acid to hydrogen sulfide.

Your answer ☐ **[1]**

An understanding of the properties of HI was required to select the correct answer, D. The most common wrong answer was C.

Question 7

7 Which statement correctly describes the reaction below?

$C_4H_9Cl + NH_3 \rightarrow C_4H_9NH_2 + HCl$

A Ammonia adds to a haloalkane to form an amine.

B Ammonia is displacing hydrogen chloride.

C An amine is formed in a substitution reaction.

D Chloropropane is reacting with ammonia.

Your answer ☐ **[1]**

A majority of candidates selected the correct answer, C, showing an understanding of the terms used here. The wrong answers were spread among the distractors.

Question 8

8 Which of these compounds will have the highest boiling point?

A CH_3CHO

B CH_3CH_2OH

C $HOCH_2CH_2OH$

D CH_3OCH_3

Your answer ☐ **[1]**

Most candidates realised that ethane-1,2-diol would form twice as many hydrogen bonds per molecule than ethanol and that the other two would not form hydrogen bonds at all, leading them to the correct answer, C.

Question 9

9 What is the final stage in the purification of a liquid organic product?

A distillation

B drying

C neutralisation

D separation

Your answer ☐ **[1]**

The majority of candidates chose the correct response, A, with the remainder choosing between B and D.

Question 10

10 What is a correct formula for an iron salt?

A $FeCO_3$

B $Fe_2(NO_3)_3$

C $FeNO_3$

D Fe_2SO_4

Your answer ☐ **[1]**

This question proved difficult, with many candidates selecting D, instead of the correct response, A. Candidates need to know the charges on common ions.

Question 11

11 Which molecule has the largest bond angle?

A BF_3

B CHF_3

C NF_3

D PF_3

Your answer [ ] **[1]**

A majority selected the correct response, A, realising that boron trifluoride is trigonal.

Question 12

12 Ethene is reacted with the reagents shown below.

Which row correctly describes the products?

	Hydrogen and platinum	**Hydrogen bromide**	**Steam/phosphoric acid with heat and pressure**
A	ethane	1,2-dibromoethane	ethanal
B	ethane	bromoethane	ethanol
C	no reaction	1,2-dibromoethane	ethanol
D	no reaction	bromoethane	ethanal

Your answer [ ] **[1]**

Candidates showing an understanding of the reactions of ethene selected the correct response, B. Wrong answers were roughly equally split between C and D.

Question 13

13 What mass of Na_2CO_3 is needed to make up 250 cm^3 of a 0.100 mol dm^{-3} solution?

(Na, 23; C, 12; O, 16)

A 2.65 g

B 3.57 g

C 10.6 g

D 26.5 g

Your answer [ ] **[1]**

It was good news that most candidates got this mole calculation correct, selecting A. A smattering of D responses presumably indicated candidates who had not realised that the sodium carbonate was 0.1 mol dm^{-3}.

Question 14

14 A compound has the structure shown.

What is a correct property of this compound?

A It fizzes with NaOH(aq).

B It gives a purple colour with neutral iron(III) chloride.

C It is neutral in solution.

D When it is heated with acidified dichromate(VI), a green solution is formed.

Your answer [ ] **[1]**

Candidates with a good understanding of functional group reactions selected the correct answer, D; many of the rest thought a phenol was present and gave B.

Question 15

15 Silver nitrate solution, followed by ammonia solution, is added to solutions of the potassium halides.

What is correct?

A Potassium bromide gives a yellow precipitate, soluble in ammonia.

B Potassium chloride gives a white precipitate, soluble in ammonia.

C Potassium iodide gives a purple precipitate, insoluble in ammonia.

D Potassium iodide gives a white precipitate, partially soluble in ammonia.

Your answer ☐ **[1]**

It was pleasing to see that the majority of candidates had learned this and selected the correct answer, B.

Question 16

16 The density of a gas is given by mass/volume.

What is a correct expression for the density?

A p/RT

B $M_r p/RT$

C RT/p

D $p/M_r RT$

Your answer ☐ **[1]**

This question was more challenging, and candidates who selected the correct answer, B, showed good algebraic ability. The most common wrong answer was D, showing that candidates realised that the '*n*' in $pV = nRT$ was given by (mass ÷ M_r) but did not carry this through correctly.

Question 17

17 How many **unsaturated** structural and *E*/*Z* isomers of butene are there?

A 3

B 4

C 5

D 6

Your answer [ ] **[1]**

Fewer candidates selected the correct response, B. Many candidates had doodled structures (arguably necessary in order to answer this question) and analysis of responses showed slightly more had omitted 2-methyl propene than any other isomer.

Question 18

18 The mass spectrum of $(C_3H_7)_2O$ has peaks at *m*/*z* 103, 102, 43 and other values.

What is correct?

A 102 is caused when the molecule gains an electron in the mass spectrometer.

B 103 is caused by the presence of ^2H in the molecule.

C The peaks at other values are caused by fragments of the molecule.

D The peak at 43 is caused by impurities.

Your answer [ ] **[1]**

A majority of candidates correctly selected C, showing they understood mass spectra. The most common wrong answer was D which showed a lack of understanding of fragmentation.

Question 19

19 Ammonia is made by the following reaction.

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

$40\,cm^3$ of hydrogen is reacted with excess nitrogen.
$10\,cm^3$ of ammonia is found in the equilibrium mixture.
All volumes are measured at the same temperature and pressure.

What volume of hydrogen remains?

A $15\,cm^3$

B $20\,cm^3$

C $25\,cm^3$

D $30\,cm^3$

Your answer ☐ **[1]**

Few candidates selected the correct answer, C. A mix of wrong answers were seen, although D was most prominent.

Question 20

20 What represents the enthalpy change of neutralisation of sulfuric acid?

A $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

B $\frac{1}{2}H_2SO_4 + NaOH \rightarrow \frac{1}{2}Na_2SO_4 + H_2O$

C $H_2SO_4 + 2Na \rightarrow Na_2SO_4 + H_2$

D $\frac{1}{2}H_2SO_4 + Na \rightarrow \frac{1}{2}Na_2SO_4 + \frac{1}{2}H_2$

Your answer ☐ **[1]**

Misconception

? Many candidates selected A, instead of the correct answer, B, presumably not realising that enthalpy change of neutralisation is defined **per mole of water formed**.

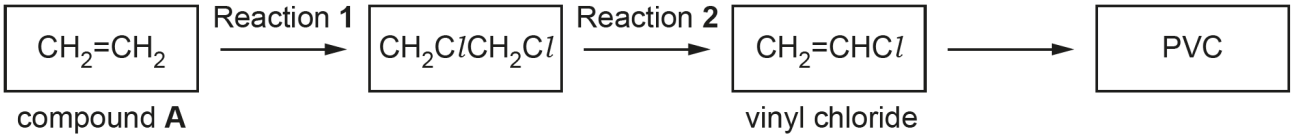
Section B overview

Most candidates tackled this part with determination and followed the exam technique rule: 'If in doubt, write something relevant'. Responses were presented clearly in most cases.
There were no indications that time was a problem. Questions 21, 22 and 24 were of roughly equal difficulty, with Question 23 being found the hardest by candidates.

Question 21 (a) (i)

21 Vinyl chloride, CH_2CHCl, is an important industrial chemical as it can be polymerised to make the polymer polyvinyl chloride, PVC.

The flowchart below shows how PVC is made.



compound **A** vinyl chloride

(a) (i) Give the systematic names for compound **A** and vinyl chloride.

compound **A** .....

vinyl chloride .....

[2]

Most candidates were given the mark for 'ethene'. Fewer candidates correctly names vinyl chloride as 'chloroethene' .

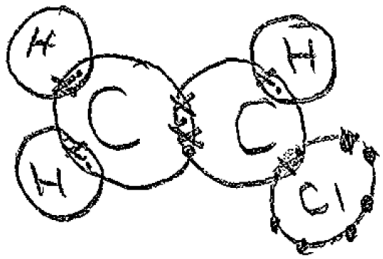
Question 21 (a) (ii)

(ii) Draw a dot-and-cross diagram for vinyl chloride.

[2]

Many candidates answered this question correctly, with the main error being omission of the lone pairs around the chlorine atom. Some candidates got confused trying to allocate a different symbol for the electrons from each atom. This is unnecessary; alternating dots and crosses will do fine.

Exemplar 1



Exemplar 1 is given both marks, but it indicates the perils of using circles (which are not necessary). Some candidates over-wrote previous diagrams which made their response confusing. Such candidates should have crossed out their first incorrect diagram and re-drawn the correct one to the side of the original.

Question 21 (a) (iii)

(iii) Give the reagent for Reaction **1**.

..... **[1]**

Most candidates wrote 'chlorine' or 'Cl_2'. The most common wrong answer was HCl.

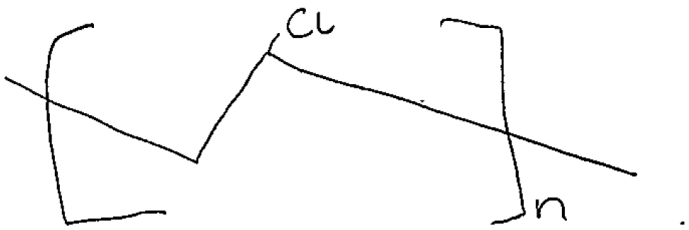
Question 21 (a) (iv)

(iv) Draw the repeating unit of the structure of PVC.

[1]

A majority of candidates scored the mark here. It is safest to answer such questions using full structural formulae, then brackets and 'n' are optional, as the repeating unit is asked for. Skeletal structures were accepted but these must have brackets. A few candidates gave two or more repeating units which were not accepted.

Exemplar 2



Exemplar 2 shows a skeletal structure and includes the brackets, so is given the mark.

Question 21 (b)

(b) Vinyl chloride reacts with HBr in an electrophilic addition reaction. Possible products are CH_2BrCH_2Cl and $CH_3CHBrCl$.

There is not an equal mix of products. The carbocation with more hydrogen atoms on one of its carbon atoms is the more stable.

Predict the **main** product of the reaction, giving your reasons.

.....

.....

.....

..... **[2]**

This was intended to be a testing question. Very few candidates scored the first mark as the structure of the more stable carbocation had to be given. Slightly more scored the second mark for describing the attack of Br^- on the carbocation.

Question 21 (c)

(c) Both compound **A** and vinyl chloride have instantaneous dipole-induced dipole intermolecular bonds. Vinyl chloride also has permanent dipole-permanent dipole intermolecular bonds.

Explain how both these types of intermolecular bonds arise and predict, with a reason, which of compound **A** and vinyl chloride has the higher boiling point.

.....

.....

.....

.....

.....

..... **[5]**

Overall, candidates showed a sound understanding of the two sorts of intermolecular forces involved here and many were able to write coherently about them. The mark most often omitted was for the attraction of permanent dipoles on adjacent molecules. Some candidates confused atoms and molecules. Other candidates just focused on predicting which compound had the higher boiling point, with many answering this part by referring to melting point.

Question 22 (a) (i)

22 The American Environmental Protection Agency (EPA) describes ozone as 'Good up high, bad nearby'.

(a) (i) State **two** polluting effects of ozone in the **troposphere**.

1. .....

.....

2. .....

.....

[2]

Most candidates scored at least one mark here.

Question 22 (a) (ii)

(ii) According to the EPA, exposure to 0.07 ppm of ozone for 8 or more hours is dangerous.

A scientist measures the ozone concentration in the air of a town as 1.0×10^{-6} %.

Is this a dangerous ozone concentration? Show your calculation.

[1]

This was an easy question for candidates who could correctly convert ppm to %, or vice-versa. Occasionally, candidates did not state the units of the quantities being compared.

Question 22 (b)

(b) In the stratosphere, ozone acts as a sunscreen, blocking out high-energy UV radiation.

Give **one** way in which high-energy UV is harmful to humans.

.....

..... **[1]**

Most candidates scored here, although responses of just 'cancer' were not given the mark.

Question 22 (c) (i)

(c) Chloroalkanes decompose to chlorine radicals in the stratosphere.

(i) Chlorine radicals catalyse the breakdown of ozone.

The catalytic process can be shown by two equations. Write the equation for **reaction 22.2**.

$Cl + O_3 \longrightarrow ClO + O_2$ **Reaction 22.1**

Reaction 22.2

[1]

This question discriminated well. Candidates either wrote the 'expected' equation ($ClO + O \rightarrow Cl + O_2$) or an accepted alternative that regenerated Cl.

Question 22 (c) (ii)

(ii) Give the equation for a possible termination reaction to end this sequence.

[1]

As in the previous part, this question discriminated well and showed the candidates who understood radical mechanisms and could write an equation for an accepted termination reaction.

Question 22 (d)

(d) CH_3CH_2Cl is a chloroalkane that decomposes in the stratosphere.

$CH_3CH_2Cl \rightarrow CH_3CH_2 + Cl$ **Reaction 22.3**

The bond energy of the C–C*l* bond is +346 kJ mol^{-1}.

Calculate the frequency of radiation required to break this bond.

frequency = ... Hz **[3]**

Another good discriminator, with a fair proportion of candidates scoring three marks. Some candidates were confused between frequency and wavelength, some did not convert kJ to J, and others did not include N_A. The standard of layout of mathematical answers has declined a little since 2019; candidates must be aware that partial credit for wrong answers can be given, but only if their working is clear.

Question 22 (e)

(e) CH_3CH_2Cl reacts with hydroxide ions as shown in **reaction 22.4**.

$CH_3CH_2Cl + OH^- \rightarrow CH_3CH_2OH + Cl^-$ **Reaction 22.4**

Compare **reactions 22.3**, in part **(d)**, and **22.4** in terms of their mechanisms and the way the C–C*l* bond is broken.

.....

.....

.....

.....

..... **[4]**

Candidates found this question difficult. To score, mechanisms could have simply been described as 'radical' (most often missed) and 'nucleophilic substitution', even though more detailed mechanisms involving curly arrows and half-curly arrows (rarer) were accepted. The bond-breaking processes needed were 'homolytic' and 'heterolytic'. Some candidates successfully described these in words ('one electron in the bond transferred to each atom' and 'both electrons in the bond transferred to Cl') although others attempting this revealed a lack of understanding.

Question 23 (a)

23 Sodium hypochlorite, NaOCl, is a chemical present in chlorine bleaches.

It acts as a bleach by oxidising stains to colourless compounds.

(a) Give the systematic name for NaOCl.

..... **[1]**

Few candidates got this right. The most common wrong answer was 'sodium oxychloride'. Candidates need instruction in naming oxo-anions.

Question 23 (b) (i)

(b) Sodium hypochlorite is made by electrolysing brine, NaCl(aq), and allowing the products to mix.

(i) Give the half-equation for the reaction at the **positive** electrode when NaCl(aq) is electrolysed.

[1]

Successful candidates gave the equation for the formation of chlorine from chloride, but this sequence of electrolysis half-equations needs practice.

Question 23 (b) (ii)

(ii) Give the half-equation for the production of hydroxide ions (and a gas) at the **negative** electrode when NaCl(aq) is electrolysed.

[1]

Relatively few scored here, reinforcing the comment above. Candidate errors included unbalanced equations and attempts to put the electrons on the wrong side.

Question 23 (b) (iii)

(iii) Suggest the equation for the two electrode products reacting to give OCl^- ions.

[1]

This probably looked hard to candidates but, in fact, a lot of help is given in the previous questions. Many had identified chlorine correctly in (b) (i) and hydroxide ions are described as the product in (b) (ii). Candidates should be encouraged to 'look for clues in the question'.

Question 23 (c) (i)

(c) The concentration of a bleach in solution can be measured by reacting the bleach with acidified iodide ions. The iodine that is formed is then titrated with sodium thiosulfate solution.

$OCl^- + 2I^- + 2H^+ \longrightarrow Cl^- + I_2 + H_2O$ **Equation 23.1**

$2S_2O_3^{2-} + I_2 \longrightarrow S_4O_6^{2-} + 2I^-$ **Equation 23.2**

(i) State which atoms are being oxidised in **equation 23.2** and give their change in oxidation state.

..... is being oxidised from ..... to .....**[2]**

Most candidates could identify sulfur, although quite a few gave iodine (and '0 to -1'). Having identified sulfur, the next hurdle was the +2.5, although a reasonable number achieved this. Plus signs were nearly always given.

Question 23 (c) (ii)

(ii) A group of students measure out 25 cm^3 of a bleach solution in a measuring cylinder and pour it into a conical flask. The students add excess hydrochloric acid and excess potassium iodide solution. They are supplied with 1.60 $mol\,dm^{-3}$ sodium thiosulfate solution.

Describe how the students should go on to obtain the results to calculate the average titre of sodium thiosulfate needed. They add starch solution near the end point.

.....

.....

.....

.....

.....

..... **[3]**

The advice to 'read the question' was key here. How much of the titration procedure was required? Some candidates just concentrated on repeated readings, but some did not mention these altogether. A few could not remember the name 'burette' and the second mark, for the endpoint, was probably only scored by those who could remember carrying out an iodine-thiosulfate titration.

Question 23 (c) (iii)

(iii) The students find that 25 cm^3 of the bleach solution needs 20.3 cm^3 of 1.60 mol dm^{-3} sodium thiosulfate.

Calculate the concentration of NaOC*l* in the bleach solution in g dm^{-3}.

Give your answer to an **appropriate** number of significant figures.

concentration of NaOC*l* = ... g dm^{-3} **[4]**

Another calculation where quite a few candidates would have benefited from laying out their calculation more clearly. For example, the number 0.0325 was often seen when the final answer was wrong, but could not be given the first marking point unless it was described in some way as 'moles of thiosulfate'. Many candidates did not insert the factor of 0.5 in calculating the concentration of chlorate(I) and did not realise that '25 cm^3' was to two significant figures meaning this number of significant figures should be used in the answer.

Question 23 (c) (iv)

(iv) The students are told that they should have used a volumetric pipette rather than a measuring cylinder to measure out 25 cm^3 of bleach.

What effect would this have on your answer to **part (iii)**?

.....

..... **[1]**

A common error made by candidates here was to talk about the measurement rather than the calculated answer.

Question 24 (a)

24 Some students study the equilibrium shown in **equation 24.1**.

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$ $\Delta H = +58\,kJ\,mol^{-1}$ **Equation 24.1**

(a) The reaction is in dynamic equilibrium.

Describe what is happening to the concentrations of the gases and the rates of the forward and back reactions at equilibrium.

concentrations .....

.....

rates .....

.....

[2]

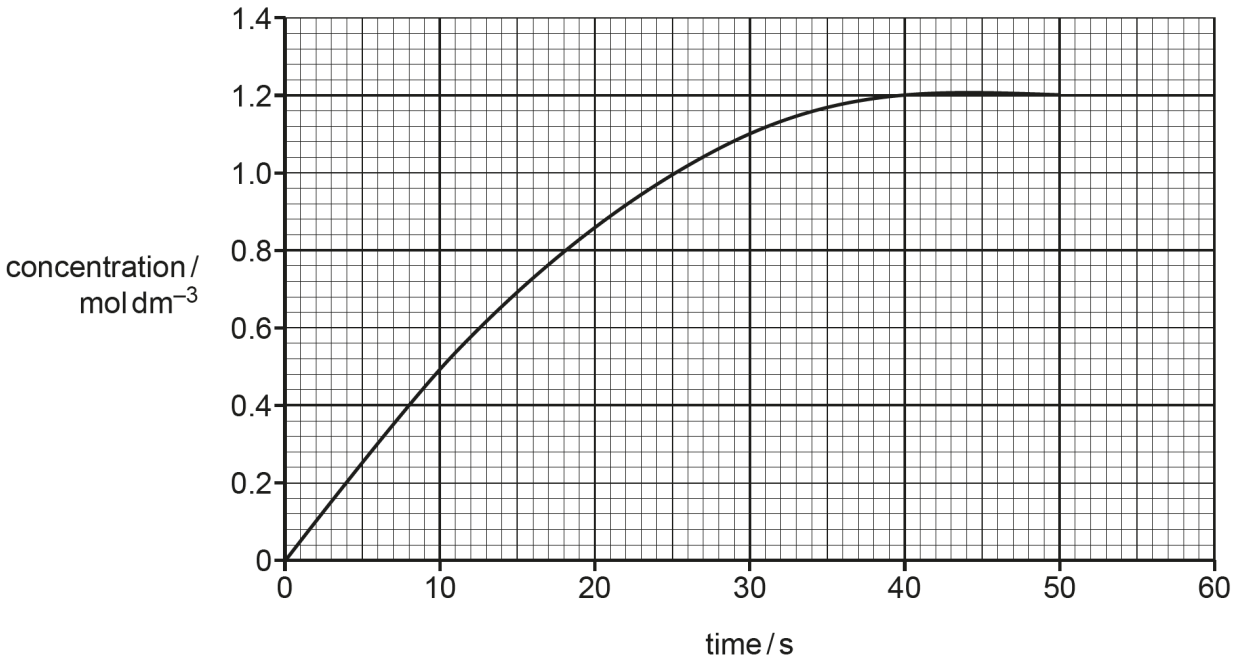
Many candidates got this right, showing a good understanding of dynamic equilibrium. It was also a test of careful use of language, distinguishing between 'constant' and 'equal'.

Question 24 (b)

At 298 K mostly N_2O_4 is present in the equilibrium in **equation 24.1**.

A 1.0 dm^3 flask contains the equilibrium mixture at 298 K.

The flask is placed in an oil bath at 600 K and the students find data for the changing NO_2 concentration. They plot these on the graph below.

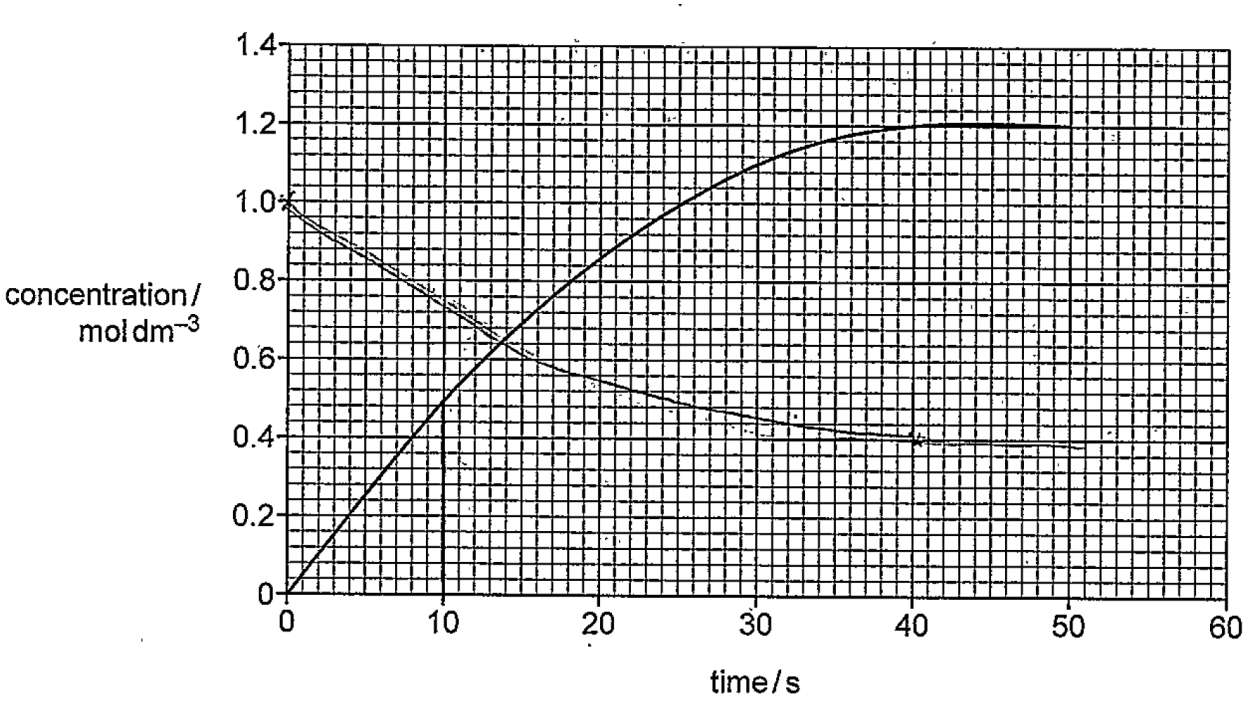


(b) The concentration of N_2O_4 starts at 1.0 mol dm^{-3} and reaches equilibrium again at 0.40 mol dm^{-3}.

Sketch a line on the axes above to show how the concentration of N_2O_4 changes. **[2]**

Examiners had to ignore lines that had been partially rubbed out, as there was no chance of being able to re-draw in a different place. The first mark was for a line starting at (0,1.0) and reaching 0.4 at 40s (realising that equilibrium would be reached when the NO_2 concentration levelled out). The second mark was for the shape of the curve. Nearly all had curved upper portions (rather than straight lines) but some wobbled at the end. Use of a ruler for the horizontal portion would have been useful.

Exemplar 3



Exemplar 3 is given the first mark, but not the second as there is a discontinuity at (40, 0.4) and the line drifts below the horizontal 0.4 line.

Question 24 (c)

(c) Use data from the graph to calculate the numerical value of K_c for the equilibrium in **equation 24.1** at 600 K.

K_c value = ... **[2]**

Many candidates scored both marks here, with just a few being given only one mark, usually for the correct formula for K_c.

Question 24 (d)

(d) Use **equation 24.1** to explain why more NO_2 is formed at 600 K, compared with 298 K.

.....

.....

.....

.....

.....

..... **[2]**

Most candidates stated that the (forward) reaction was endothermic. The key to scoring the second mark was the word 'equilibrium' which could be described as 'moving to the right' at the higher temperature, or other words to that effect. Vague expressions such as 'the forward reaction is favoured' on their own were not rewarded.

Question 24 (e)

(e) The students find data for repeating the experiment with the oil bath at 700 K.

They notice that after 10 s the concentration of NO_2 is 0.60 mol dm^{-3}.

Explain this observation with the relevant chemistry.

.....

.....

.....

.....

.....

..... **[2]**

A few candidates continued to describe the effect of temperature on equilibrium here. Quite a few apparently understood that the reaction was faster but did not say so for the first mark. The key to the second mark was the word 'collisions'. It is a greater frequency of collisions with energy greater than E_A that causes the faster reaction. 'Successful collisions' was allowed.

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