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AS LEVEL

Examiners' report

CHEMISTRY B (SALTERS)

H033
For first teaching in 2015

H033/01 Summer 2018 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. 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 can be downloaded from OCR.

Paper H033/01 series overview

H033/01 is one of two examination components for the AS Level examination for GCE Chemistry B. This component concentrates on some of the fundamentals required for a sound knowledge of chemistry through a mixture of multiple choice, short answer and extended response questions. Ability to perform single and multi-step calculations is required. Candidates are expected to have a sound knowledge of the properties and reactions of a range of substances; an understanding of fundamental chemical principles and the way they determine chemical and physical properties; knowledge of a range of practical techniques and the ability to apply these in novel situations.

Candidate performance

Candidates who did well provided evidence of the following:

- Mathematical skills applied within a chemical context (e.g. structured calculations, correctly constructed and labelled graphs, re-arrangement of equations).
- Clear and concise answers to extended response questions (22(a); 24(c) and 24(d)(iii)).
- Clear diagrams illustrating "dot-and-cross" and reaction mechanisms.
- Accurate, labelled diagrams.

Candidates who did less well generally did the following:

- Showed poor setting out of calculations.
- Produced poorly structured extended answers that often strayed away from the response required.
- Produced diagrams, graphs and reaction mechanisms which lacked the required degree of detail.

There was no evidence that time constraints led to underperformance. Few scripts showed high levels of no response to questions. The vast majority of candidates answered all the questions. A small number of candidates left one or more multiple choice responses empty and some others showed evidence of having changed their answer by overwriting the letter in the response box. Candidates need to be reminded that such changes should involve drawing a line through the first response and writing the second alongside.

Section A

Question 1

1 What is the correct order of radiation in order of increasing wavelength?

A ultraviolet < visible < infrared

B ultraviolet < infrared < visible

C visible < infrared < ultraviolet

D infrared < visible < ultraviolet

Your answer ☐ [1]

A – The majority of candidates had the correct order although a number gave it by increasing frequency (D)

Question 2

2 Which of the following is a cyclic saturated aliphatic compound?

A cyclohexene

B cyclohexane

C benzene

D hexane

Your answer ☐ [1]

B – Most candidates correctly identified cyclohexane

Question 3

3 What is **not** a property of hydrogen iodide?

A It reacts with ammonia.

B It is soluble in water.

C It is stable to heat.

D It reacts with sodium hydroxide.

Your answer ☐ [1]

Less than half the candidates correctly identified C. There was a relatively even spread of incorrect answers.

Question 4

4 What is the correct order of boiling points with the lowest first?

A CH_4 CH_3Cl CH_3OH

B CH_4 CH_3OH CH_3Cl

C CH_3Cl CH_3OH CH_4

D CH_3OH CH_3Cl CH_4

Your answer [ ] **[1]**

A – Most candidates gained this mark, although a number reversed the order (D)

Question 5

5 Which statement about ozone is correct?

A Ozone is a polluting gas in the stratosphere.

B Ozone acts as a sunscreen in the stratosphere.

C There is no ozone in the troposphere.

D Ozone is an isomer of oxygen.

Your answer [ ] **[1]**

B – The role of ozone is generally well known. Confusion between isomer and allotrope was evident in a few responses.

Question 6

6 A company makes a cleaning product and is looking for a 'greener' method of making the product.

Which one of the following would the company consider?

A Finding a reaction with a higher percentage yield.

B Finding a reaction with a higher atom economy.

C Using more organic solvents.

D Using inorganic catalysts rather than enzymes.

Your answer [ ] **[1]**

B – The link between "green" chemistry and atom economy is well understood but some candidates felt yield was the important consideration.

Question 7

7 Name the functional group in HCHO.

A aldehyde

B ketone

C alcohol

D carboxylic acid

Your answer ☐ **[1]**

A – the most common incorrect response was ketone (B)

Question 8

8 1.0 g of solid carbon dioxide is vaporised.
What volume of gas (in cm^3) is produced at RTP?

A 0.55

B 24

C 550

D 24 000

Your answer ☐ **[1]**

C – Higher ability candidates gained this mark. Lower ability candidates tended to choose A or D

Question 9

9 What is the percentage of chlorine by mass in magnesium chloride?

A 59%

B 66%

C 74%

D 75%

Your answer ☐ **[1]**

D – Most candidates achieved this mark, although there was evidence from use of the blank space alongside that the formula of magnesium chloride was not always known.

Question 10

10 Which statement about the reactions of solid halides with concentrated sulfuric acid is correct?

A Chlorides produce HC*l* as the only gas.

B Bromides produce HBr, Br_2 and H_2S.

C Iodides produce HI, I_2 and SO_2.

D Astatides would be expected to produce HAt only.

Your answer ☐ **[1]**

A – Few candidates answered correctly. Together with question 3 this suggests that practical work on the halides is not well learnt.

Question 11

11 Which statement about electronegativity is correct?

A Electronegativity is the charge on an element's ion.

B If a bond is polar, the two atoms have different electronegativities.

C If a molecule has no dipole, all its atoms have the same electronegativity.

D Electronegativity increases down a group of the Periodic Table.

Your answer ☐ **[1]**

B- The link between electronegativity and bond polarity is well understood.

Question 12

12 Which substance does **not** have hydrogen bonding between its molecules?

A C_6H_5OH

B CH_3CHO

C CH_3COOH

D C_3H_7OH

Your answer ☐ **[1]**

B – The structural requirements for hydrogen bonding are well understood by all but the least able candidates.

Question 13

13 Which statement about the flame colour of lithium is correct?

A It is yellow.

B It is caused by electrons absorbing visible light.

C It is the result of bright lines in lithium's emission spectrum.

D It follows a pattern of colours in Group 1.

Your answer ☐ **[1]**

C – A significant number of candidates of all abilities confused emission and absorption.

Question 14

14 $35\,cm^3$ of a solution has a concentration of $0.125\,mol\,dm^{-3}$.
A student calculates the amount (in moles) of solute in this solution.

Which answer is given to the appropriate number of significant figures?

A 4.37×10^{-3}

B 4.375×10^{-3}

C 4.38×10^{-3}

D 4.4×10^{-3}

Your answer ☐ **[1]**

D – Few candidates gained this mark. No calculation was required.

Question 15

15 Hydrochloric acid reacts with sodium carbonate as shown in the equation.

$$2HCl + Na_2CO_3 \rightarrow 2NaCl + CO_2 + H_2O$$

$20\,cm^3$ of $2.0\,mol\,dm^{-3}$ Na_2CO_3 are added to $20\,cm^3$ $2.0\,mol\,dm^{-3}$ HCl.

What mass of CO_2 (in g) is produced?

A 0.88

B 1.76

C 22

D 1760

Your answer ☐ **[1]**

A – Higher ability candidates gained this mark, but a significant number across all abilities did not recognise that the limiting reagent was HCl and chose B. Most candidates made some use of the blank space for calculations.

Question 16

16 A sample of gas has a mass of m g and occupies a volume $V\,m^3$ at a pressure p Pa and temperature T K.

Which expression is correct for the M_r of the gas?

A mRT/pV

B pV/mRT

C pV/RT

D mRT/npV

Your answer ☐ **[1]**

A – Candidates had difficulty substituting M_r into the gas equation then rearranging. Most chose B or C

Question 17

17 Which statement about carboxylic acids is correct?

A They can be made by oxidising secondary alcohols.

B They react with phenols.

C They do **not** fizz with sodium carbonate solution.

D They form esters when reacted with tertiary alcohols.

Your answer [ ] **[1]**

D – The most able candidates gained this mark but generally the reactions of carboxylic acids were not well known. All three incorrect responses were well represented.

Question 18

18 What is **not** a consequence of hydrogen bonding?

A Water expands on freezing.

B Ethanol is very soluble in water.

C Sodium chloride dissolves in water.

D H_2O has a higher boiling point than H_2S.

Your answer [ ] **[1]**

C – Over half the candidates gave the correct response. All three incorrect responses were well represented.

Question 19

19 Which statement about a lattice of sodium chloride is correct?

A The ions are the same size.

B The attraction between two sodium ions is greater than the repulsion between two chloride ions.

C Each sodium ion is surrounded by six chloride ions.

D There are more sodium ions than chloride ions.

Your answer [ ] **[1]**

C – Most higher ability candidates gave the correct answer. The most common incorrect response was B

Question 20

20 Which row is correct?

	Name	Formula
A	sodium nitride	Na_3N
B	aluminium sulfate	$AlSO_4$
C	copper(I) oxide	CuO
D	calcium hydroxide	$CaOH_2$

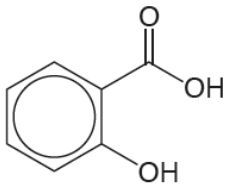
Your answer [ ] **[1]**

A – Most higher ability candidates gave the correct answer but many chose C or D

Section B

Question 21 (a)

21 Aspirin is a medicine that reduces fever and relieves pain.
Some students prepare a sample of aspirin from salicylic acid.



salicylic acid

(a) Before the students start the preparation, they test the salicylic acid with iron(III) chloride.

What colour would they see?

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

The majority of candidates recognised this test for phenols but a few stated the colour would be green rather than purple.

Question 21 (b) (i)

(b) The students then make aspirin by warming 6.0 g of salicylic acid with 10 cm^3 of ethanoic anhydride in the presence of concentrated sulfuric acid.

$HOOCC_6H_4OH$ + $(CH_3CO)_2O$ → $HOOCC_6H_4OCOCH_3$ + ...

salicylic acid ethanoic anhydride aspirin

(i) Balance the equation by writing the structural formula of the other product on the dotted line.

[1]

This was not well answered. Many candidates gave a molecular rather than unambiguous structural formula. H_2O was a common incorrect response.

Question 21 (b) (ii)

(ii) The density of ethanoic anhydride is 1.1 g cm^{-3}.

Calculate the amount (in moles) of ethanoic anhydride used.

amount of ethanoic anhydride = ... mol **[1]**

Evidence of calculation was not required for this mark. Higher ability candidates generally answered correctly (0.11) but many did not to multiply by 10 cm^3. Answers correctly rounded to 2 or more significant figures were accepted.

Question 21 (b) (iii)

(iii) Which is in excess, the salicylic acid or the ethanoic anhydride?

[2]

This question could only be answered by calculating the amount of salicylic acid. The concept of one reactant being in excess seems well known but some candidates justified a choice of ethanoic anhydride from a practical perspective e.g. "There must be an excess of anhydride to react all the salicylic acid". This response was not accepted in the context of the question.

Question 21 (c) (i)

(c) The students pour their hot solution into water and aspirin crystallises out as the water cools.

The students then look for a suitable solvent to recrystallise the aspirin.

(i) State the properties of a suitable solvent for recrystallisation.

.....

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

Higher ability candidates recognised the need for differential solubility in hot and cold solvent but fewer than half of all candidates gained this mark.

Question 21 (c) (ii)

(ii) Name a method for testing the purity of the aspirin formed.

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

Half of the responses were correct. Higher ability candidates tended to choose melting point but TLC was also common. Measurement of boiling point was quite often incorrectly given.

Question 21 (d)

(d) After recrystallisation, the students obtained 3.1 g of aspirin.

What value for the percentage yield does this give?

yield = ... % **[2]**

Higher ability candidates correctly calculated a yield in the allowed range (39 to 40.1%) but it was evident that many candidates did not understand the concept of yield. Lower ability candidates frequently divided 3.1 by the mass of salicylic acid (or by the total mass of reagents).

Question 21 (e)

(e) Some other students make the liquid ester ethyl ethanoate.

Name the final stage in their purification of the ester.

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

Only a minority of candidates correctly wrote distillation, with many describing methods for purifying solids e.g. filtration or recrystallisation.

Question 21 (f)

(f) The students also carry out some tests on phenol, C_6H_5OH.

They find that it is not very soluble in water but fully dissolves when sodium hydroxide solution is added.

A student says that this shows that phenol is acidic and thus it should fizz with sodium carbonate solution.

Comment on the student's statement.

.....

.....

.....

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

There were a number of very good answers to this question. Most candidates recognised that phenol was acidic and higher ability candidates understood that it was too weak to react with sodium carbonate. Some lower ability candidates phrased their answers in terms of phenol being either an alcohol or a base due to the –OH group. Some candidates stated that only carboxylic acids react with carbonates.

Question 22 (a)

22 In 1875 a French chemist saw two violet lines in an emission spectrum that did not correspond to any known element. He isolated the metal responsible and named it gallium, Ga, after his country.

(a) Explain why each element has a characteristic emission spectrum.

.....

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.....

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

There were some excellent answers to this question which covered the four marking points succinctly, but many responses lacked a clear, logical layout. Some candidates did not mention electrons and many answers did not specifically make the link between energy loss and frequency of radiation emitted. There was clear confusion in some cases between electron configuration and energy levels and many candidates did not clearly write why different elements had different spectra. A small number of candidates mentioned atoms or elements moving up and down levels. Some candidates confused absorption and emission.

Question 22 (b) (i)

(b) (i) Complete the electron configuration of gallium, Ga.

$1s^2 2s^2 2p^6 3s^2 3p^6$ ..... **[1]**

Most candidates gained this mark. Very few candidates used subscripts instead of superscripts and only a few used capital letters. The most common mistake was $4d^{10}$ instead of $3d^{10}$.

Question 22 (b) (ii)

(ii) Describe the shape of an s-orbital.

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

This question was not well answered. Many candidates do not appear to differentiate between a 2D circle and a 3D sphere. A significant number thought that the s-orbital is dumbbell shaped.

Question 22 (b) (iii)

(iii) Give the charge on the cation of gallium predicted by its position in the Periodic Table.

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

The vast majority of candidates correctly gave 3+, although often with the positive sign before the number. A small number of negative answers (including -5) show that some candidates are still unclear of the distinction between cation and anion.

Question 22 (c) (i)

(c) Gallium forms an anion with chlorine, $GaCl_4^-$. This is thought to have covalent bonds between a gallium atom and three chlorine atoms and a dative covalent bond from a chloride ion to the gallium atom.

(i) Draw a '*dot-and-cross*' diagram of $GaCl_4^-$.

[2]

Most candidates correctly drew the section of the ion comprising the three shared pairs of electrons and many correctly drew the dative pair. However, many did not put in the extra electron on the chloride and a small but significant number did not include the non-bonding pairs. A few candidates attributed the dative pair to the gallium atom by the incorrect use of dot-and-cross. It was clear from the scripts that some candidates had made multiple attempts at the diagram. In such cases, candidates would be strongly advised to draw a line through the first attempt and draw the second alongside, rather than rubbing out and over-drawing their final attempt.

Question 22 (c) (ii)

(ii) Name the shape of $GaCl_4^-$.

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

Most candidates correctly described the shape as tetrahedral. The most common mistake was trigonal pyramid. Very few chose square planar.

Question 22 (d)

(d) Gallium has two isotopes, ^{69}Ga and ^{71}Ga.
The A_r of gallium is 69.7.

Calculate the relative abundance of ^{69}Ga as a percentage.

relative abundance of ^{69}Ga = ... % **[2]**

Many candidates successfully used the standard method for calculating the relative abundance, although some calculated the abundance of ^{71}Ga rather than ^{69}Ga. A few used the difference in isotopic masses successfully. A large number of candidates did not know either method and simply averaged the two isotope masses.

Question 23 (a) (i)

23 Ethene, C_2H_4, is the simplest alkene and has a wide variety of uses in industry, especially in making polymers.

Ethene is made by the catalytic cracking of longer hydrocarbons, such as those in light naphtha.

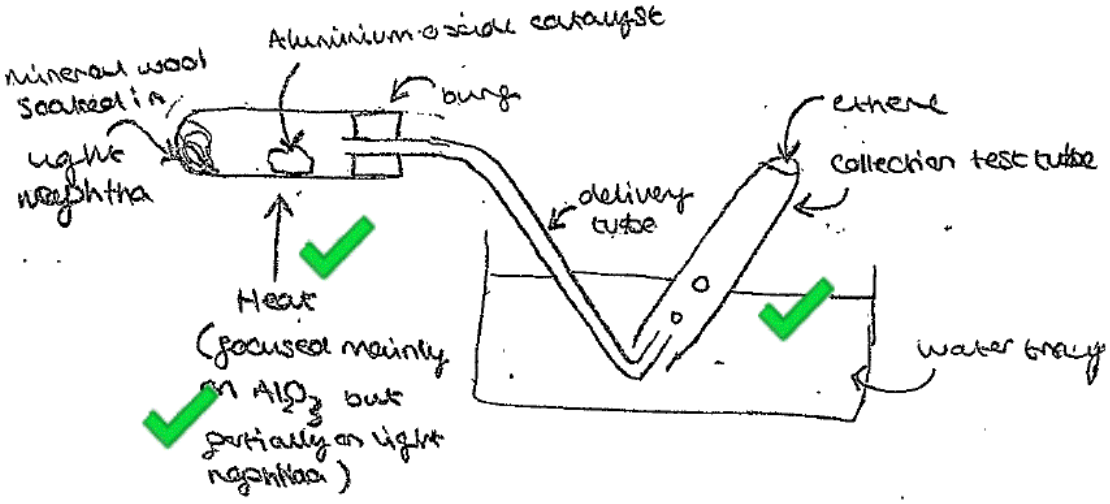
(a) Some students are given a supply of liquid light naphtha and they need to obtain some ethene from it. They use aluminium oxide as the catalyst.

(i) Draw a labelled diagram of a suitable apparatus that they could use.

[3]

The majority of diagrams from candidates of all abilities were of poor quality and many candidates displayed very limited awareness of catalytic cracking. Very few candidates showed (or described) heat being applied to both the naphtha and the aluminium oxide and a number tried to collect the ethane in either a sealed tube or a conical flask. The majority of responses showed the catalyst lodged half way up the boiling tube containing naphtha (rather than in a separate tube) but a small minority showed the catalyst mixed with the naphtha.

Exemplar 1



[3]

Although two separate sources of heat are not shown, this candidate has clearly indicated that heat must be applied to both the catalyst and the naphtha. Heating the catalyst in a separate tube would have been preferred but was not essential.

Question 23 (a) (ii)

(ii) They test the gas by shaking it with some aqueous bromine.

Describe the colour **change** that they would see.

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

The majority of candidates correctly described the colour change. Most incorrect responses had the colour change inverted. A few candidates used the word "clear" rather than "colourless".

Question 23 (a) (iii)

(iii) Draw the mechanism for the reaction of ethene with Br_2.

Show curly arrows, full charges and the product.

[3]

It is clear that the majority of candidates are familiar with this reaction mechanism and higher ability candidates often gained full marks. Most candidates were able to correctly identify the final product. The major problems experienced by candidates were the positioning and direction of curly arrows in the first step and the full charges on the carbocation and bromide in the second. Curly arrows must clearly start at a bond or pair of electrons and finish at an atom or the position between the atoms where the new bond forms.

Question 23 (b) (i)

(b) Catalytic cracking uses a heterogeneous catalyst.

(i) State how catalysts work in terms of the activation enthalpy.

.....

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

Mention of an alternative pathway was required. A significant number of candidates referred to the activation enthalpy being reduced without reference to the alternative route.

Question 23 (b) (ii)

(ii) The students research a simple model of the function of a heterogeneous catalyst.

Name the way the hydrocarbon molecules in light naphtha first attach to the catalyst surface.

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

Very few candidates mentioned "adsorption" but most gained the mark for "adsorbs". The most common mistake was "adsorbtion". A small minority of candidates were more specific, mentioning chemisorption or physisorption, both of which were allowed.

Question 23 (c) (i)

(c) Ethene can be converted to chloroethene, C_2H_3Cl.

(i) Draw the **skeletal** formula for chloroethene.

[1]

Most candidates of all abilities were able to draw this formula.

Question 23 (c) (ii)

(ii) A student says that chloroethene shows *cis-trans* isomerism.

Is the student correct? Explain your answer.

.....

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

Although a large number of candidates said that *cis-trans* isomerism was not possible, very few were able to explain why. A significant number thought that two chlorine atoms were required for *cis-trans* rather than focussing on the two identical species attached to one of the carbon atoms. Some were clearly confused between *E/Z* and *cis-trans*.

Question 24 (a)

24 Some students research nitrogen oxides as air pollutants.

(a) Name the main polluting effect of NO_2 in the atmosphere.

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

The most common correct answers were photochemical smog and acid rain. Incorrect answers which mentioned ozone generally referred to the breakdown of (stratospheric) ozone.

Question 24 (b)

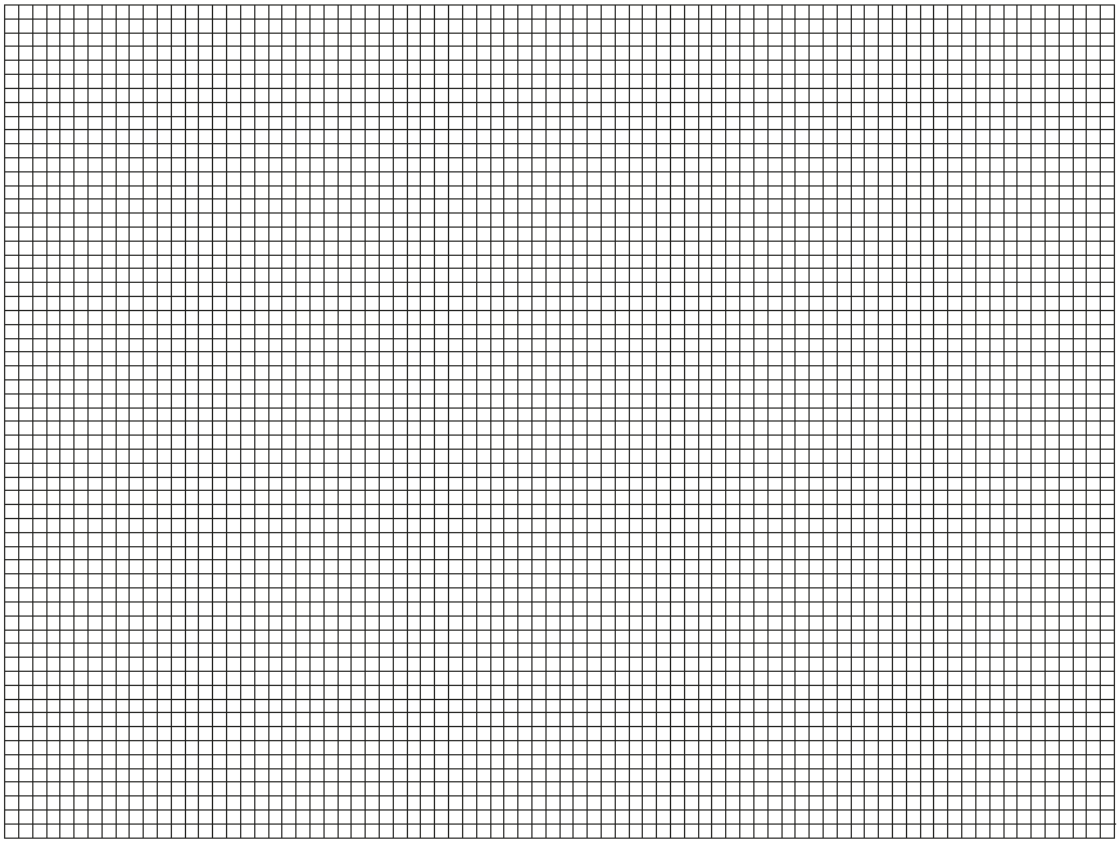
(b) The students look up some data for the experimentally measured rates of the reaction shown below.

$$2NO_2 \rightarrow 2NO + O_2$$

Their data are shown in the table below.

T/K	Relative rate
592	1.0
604	1.4
628	3.2
650	8.0
658	10.4

Plot a graph of relative rate against temperature and use it to work out the relative rate when the temperature is 615 K.



relative rate at 615 K = ... **[3]**

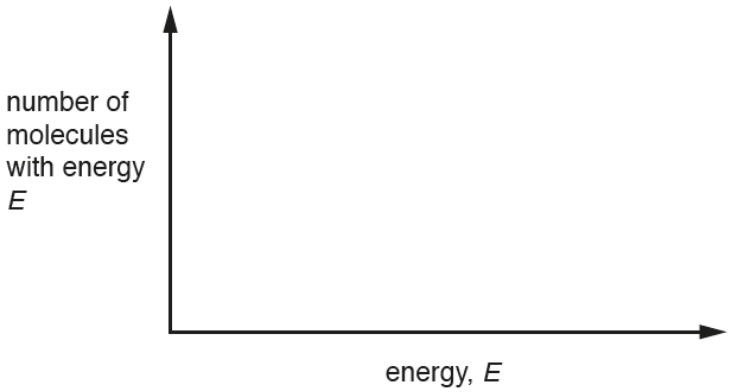
A minority of candidates reversed the axes with the independent variable on the y-axis. Some candidates omitted the units of T. Both of these were necessary for the first mark. A number of candidates continued the curve to zero on the y-axis and did not get the second mark. Most made good use of the graph space provided. The majority of candidates were able to deduce an appropriate relative rate by drawing a smooth curve.

Question 24 (c)

(c) Draw two Boltzmann distributions at different temperatures on the axes below.

Use your diagram to explain why the rate of reaction increases with temperature.

Label your diagram.



.....

.....

.....

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

Most candidates are familiar with the concept of Boltzmann distributions but the lines drawn lacked the necessary detail. The most common errors were not starting the curves at the origin and finishing the curve on the x axis. A few candidates' curves rose again at the high energy end. Most candidates drew two lines but a number did not to indicate which related to the higher temperature. Ea was shown in most cases although a few thought that the activation energy was the shaded area beyond Ea. The majority of candidates were able to relate the diagram to the increased proportion of particles having energy above Ea at higher temperature but most expressed the effect on reaction rate vaguely in terms of "success" rather than energy.

Question 24 (d) (i)

(d) The students then consider the reaction that occurs in lightning flashes:

$N_2 + O_2 \rightleftharpoons 2NO$ $\Delta_r H = +180\,kJ\,mol^{-1}$ **Equation 24.1**

(i) Complete the expression for the equilibrium constant, K_c, for this reaction.

$K_c =$

[1]

The majority of responses were correct. Lower ability candidates sometimes added rather than multiplied concentrations and a number used N and O rather than N_2 and O_2. A very small minority showed reactants on the top line.

Question 24 (d) (ii)

(ii) A student says that, when equilibrium is reached in **equation 24.1**:

- the rates of the forward and back reactions are equal
- the concentrations of NO, O_2 and NO are equal.

Comment on these statements, giving the correct chemistry where necessary.

.....

.....

.....

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

Most candidates indicated that the first statement was correct and many knew that concentrations of reactants and products were not necessarily equal and but were not able to explain their decision correctly.

We have adjusted the mark scheme to allow for a typo within this question.

Question 24 (d) (iii)

(iii) Consider and **explain** the conditions of temperature and pressure that would give the greatest equilibrium yield of NO in **equation 24.1**.

.....

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.....

.....

.....

.....

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

Many higher ability candidates gained full marks through well structured responses. Answers were not always concise with later parts sometimes contradicting earlier statements. Most identified that the forward reaction was endothermic and that the yield would increase at higher temperature. Some then did not link this to the shift in equilibrium position or wrote about the reaction moving to the right. The effect of pressure on yield was known by many in principle but a significant number of candidates were unable to recognise that the number of particles on the two sides were equal. Questions on this topic are often based on a manufacturing process and it was evident that some candidates answered the question in this context concluding their answers with statements such as "You should use high temperature and a normal pressure to get the maximum yield".

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