Write your name here

Surname

Other names

Pearson Edexcel
International GCSE

Centre Number

Candidate Number

Chemistry

Unit: 4CH0
Science (Double Award) 4SC0
Paper: 1CR

Thursday 19 May 2016 – Morning
Time: 2 hours

Paper Reference
4CH0/1CR
4SC0/1CR

You must have:
Ruler
Calculator

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – there may be more space than you need.
- Show all the steps in any calculations and state the units.
- Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Information

- The total mark for this paper is 120.
- The marks for **each** question are shown in brackets
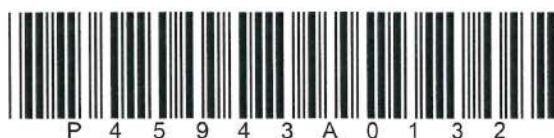 – use this as a guide as to how much time to spend on each question.

Advice

- Read each question carefully before you start to answer it.
- Write your answers neatly and in good English.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P 4 5 9 4 3 A 0 1 3 2

PEARSON

THE PERIODIC TABLE

Period

	Group 1	Group 2											Group 3	Group 4	Group 5	Group 6	Group 7	Group 0

1

1
H
Hydrogen
1

4
He
Helium
2

2

7
Li
Lithium
3

9
Be
Beryllium
4

11
B
Boron
5

12
C
Carbon
6

14
N
Nitrogen
7

16
O
Oxygen
8

19
F
Fluorine
9

20
Ne
Neon
10

3

23
Na
Sodium
11

24
Mg
Magnesium
12

27
Al
Aluminium
13

28
Si
Silicon
14

31
P
Phosphorus
15

32
S
Sulfur
16

35.5
Cl
Chlorine
17

40
Ar
Argon
18

4

39
K
Potassium
19

40
Ca
Calcium
20

45
Sc
Scandium
21

48
Ti
Titanium
22

51
V
Vanadium
23

52
Cr
Chromium
24

55
Mn
Manganese
25

56
Fe
Iron
26

59
Co
Cobalt
27

59
Ni
Nickel
28

63.5
Cu
Copper
29

65
Zn
Zinc
30

70
Ga
Gallium
31

73
Ge
Germanium
32

75
As
Arsenic
33

79
Se
Selenium
34

80
Br
Bromine
35

84
Kr
Krypton
36

5

86
Rb
Rubidium
37

88
Sr
Strontium
38

89
Y
Yttrium
39

91
Zr
Zirconium
40

93
Nb
Niobium
41

96
Mo
Molybdenum
42

99
Tc
Technetium
43

101
Ru
Ruthenium
44

103
Rh
Rhodium
45

106
Pd
Palladium
46

108
Ag
Silver
47

112
Cd
Cadmium
48

115
In
Indium
49

119
Sn
Tin
50

122
Sb
Antimony
51

128
Te
Tellurium
52

127
I
Iodine
53

131
Xe
Xenon
54

6

133
Cs
Caesium
55

137
Ba
Barium
56

139
La
Lanthanum
57

179
Hf
Hafnium
72

181
Ta
Tantalum
73

184
W
Tungsten
74

186
Re
Rhenium
75

190
Os
Osmium
76

192
Ir
Iridium
77

195
Pt
Platinum
78

197
Au
Gold
79

201
Hg
Mercury
80

204
Tl
Thallium
81

207
Pb
Lead
82

209
Bi
Bismuth
83

210
Po
Polonium
84

210
At
Astatine
85

222
Rn
Radon
86

7

223
Fr
Francium
87

226
Ra
Radium
88

227
Ac
Actinium
89

Key

Relative atomic mass
Symbol
Name
Atomic number

Answer ALL questions.

1 The Periodic Table is shown on page 2.

(a) In the Periodic Table, which number increases from 3 to 10 in Period 2?

(1)

atomic number

(b) In the Periodic Table, which number increases from 9 to 226 in Group 2?

(1)

relative atomic mass

(c) An atom of boron contains protons, neutrons and electrons.

Use words from the box to complete the sentences.

Your may use each word once, more than once or not at all.

| protons | neutrons | electrons |

(i) The particles with the smallest mass are _electrons_ .

(1)

(ii) The particles with a negative charge are _electrons_ .

(1)

(iii) The two types of particle in the nucleus of a boron atom

(1)

are _protons_ and _neutrons_ .

(iv) In a boron atom there are equal numbers of

(1)

protons and _electrons_ .

(v) The element boron has isotopes.

(1)

These isotopes have different numbers of _neutrons_ .

(Total for Question 1 = 7 marks)

P 4 5 9 4 3 A 0 3 3 2

2 In chemistry, the state symbols (s), (l), (g) and (aq) are often used.

(a) The table shows some changes of state.

Complete the table to show the state symbol before and after the change.

(3)

Change of state	State symbol before change	State symbol after change
Water boils in a kettle	l	g
Ethene is converted to poly(ethene)	g	s
Crystals of iodine sublime on heating	s	g

1.02

(b) Some marble chips are added to a solution of hydrochloric acid.

Complete the equation for the reaction that occurs by writing the appropriate state symbol after each formula.

(2)

1.25

$CaCO_3($ s $) + 2HCl($ aq $) \rightarrow CaCl_2($ aq $) + H_2O($ l $) + CO_2($ g $)$
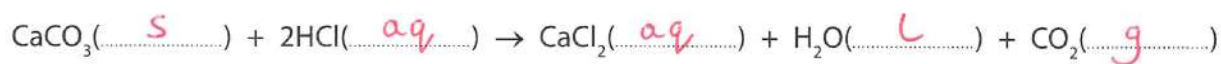
(c) Which state symbol is used most often for the elements of the Periodic Table at room temperature?

(1)

1.18

s

(Total for Question 2 = 6 marks)

3 Techniques used in the separation of mixtures include

    A   crystallisation

    B   filtration

    C   fractional distillation

    D   simple distillation

For each separation, select the most suitable technique, A, B, C or D, used to obtain the first named substance from the mixture.

Each letter may be used once, more than once or not at all.

(a) Pure water from sea water

(1)

D

(b) Ethanol from a mixture of ethanol and water

(1)

C

(c) Calcium carbonate from a mixture of calcium carbonate and water

(1)

B

(d) $CuSO_4.5H_2O(s)$ from $CuSO_4(aq)$

(1)

A

(Total for Question 3 = 4 marks)

1.10

4 The table gives information about some of the elements in Group 7 of the Periodic Table.

Element	Colour	Melting point in °C	Boiling point in °C
fluorine	yellow	−220	−188
chlorine		−101	−35
bromine	red-brown	−7	59
iodine	grey	114	

(a) What is the colour of chlorine at room temperature?

(1)

☐ **A** black

☐ **B** blue

☒ **C** green

☐ **D** orange

(b) The trend in the boiling points for these elements is similar to the trend in their melting points.

Predict a value for the boiling point of iodine.

(1)

180   (120 − 250) .... °C

(c) Astatine is another element in Group 7.

Predict its colour and physical state at room temperature.

(2)

colour .... Black ....

physical state .... Solid ....

2.05

2.05

2.06

P 4 5 9 4 3 A 0 6 3 2

(d) The elements in Group 7 have similar chemical reactions because they have the same number of

☐ **A** electrons

☐ **B** electron shells

☒ **C** outer electrons

☐ **D** protons

(e) A student wrote these statements about the reactions of the Group 7 elements.

- The reactivity of the elements decreases down the group.

- The elements form ions with a single positive charge.

- The formula of an astatine molecule is At_2

- The equation for the reaction between chlorine and potassium bromide solution is $Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2$

- In the reaction between bromine and potassium iodide, bromine acts as a reducing agent.

Three of the statements contain **one** incorrect word.

Complete the table to show each incorrect word and the correct word that should be used to replace it.

Incorrect word	Correct word
Positive	Negative
Potassium	Sodium
Reducing	Oxidising

(Total for Question 4 = 8 marks)

P 4 5 9 4 3 A 0 7 3 2

5 A student investigates the pigments found in some vegetables and fruit.

She obtains some coloured vegetable and fruit extracts from carrots, tomatoes and sweet potatoes.

She places a spot of each extract on chromatography paper, along with spots of the three pigments beta-carotene, chlorophyll and lycopene.

Her teacher provides a solvent containing volatile, flammable organic compounds for the experiment. The diagram shows the apparatus at the start of the experiment.
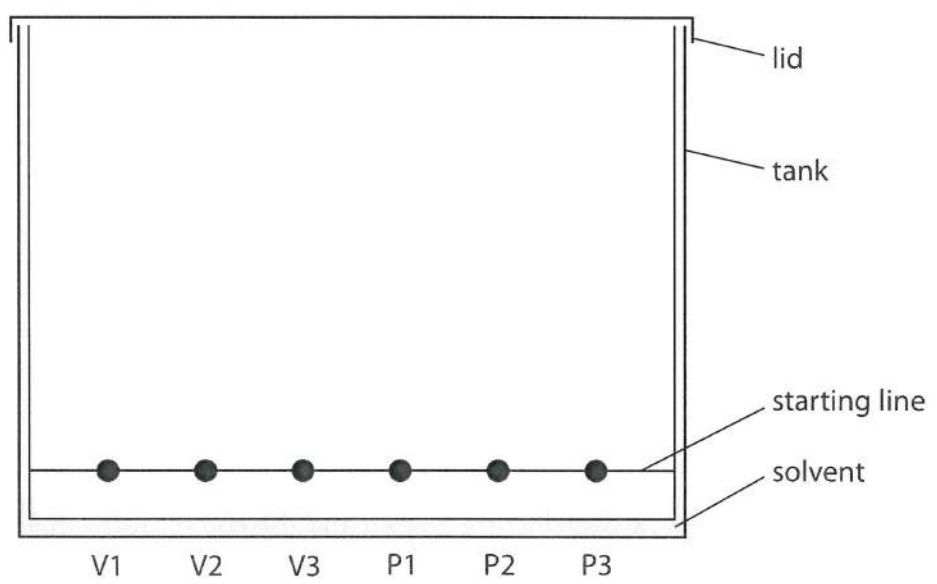
Key to vegetable and fruit extracts and pigments

V1 = carrots   V2 = tomatoes   V3 = sweet potatoes

P1 = beta-carotene   P2 = chlorophyll   P3 = lycopene

(a) (i) Explain why it is important for the solvent level to be below the spots.

Prevent them dissolving / mixing

(ii) State two potential problems that are prevented by fitting the tank with a lid.

ANY 2

1 ....

• Evaporation

2 ....

• Risk of fire

• Fumes may be toxic

1.10

1.10

1.10

P 4 5 9 4 3 A 0 8 3 2

(b) The diagram shows the chromatogram at the end of the experiment.
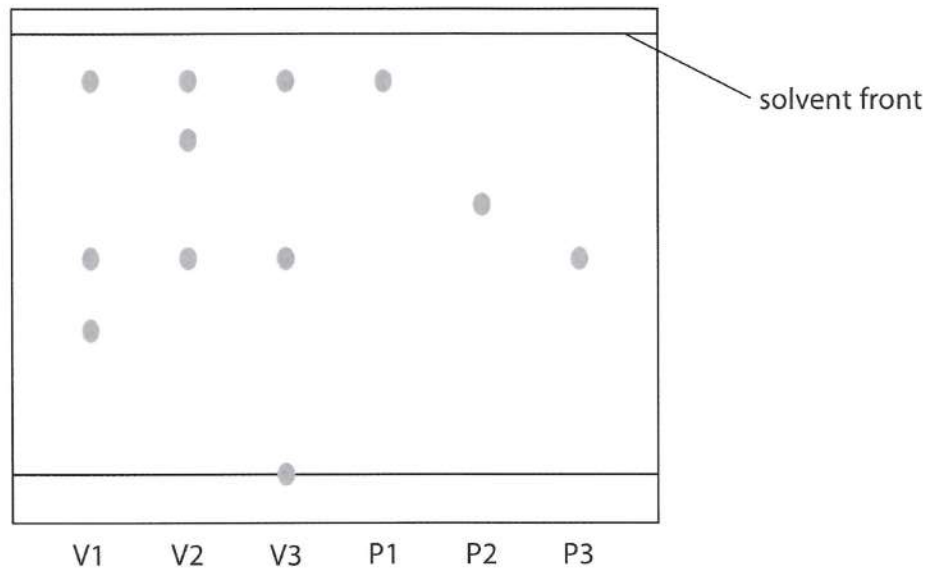
solvent front

V1   V2   V3   P1   P2   P3

Key to vegetable and fruit extracts and pigments

V1 = carrots   V2 = tomatoes   V3 = sweet potatoes

P1 = beta-carotene   P2 = chlorophyll   P3 = lycopene

Which three of the statements A, B, C, D and E are supported by the chromatogram?

Place a cross in three boxes to indicate your choice.

(3)

A   Chlorophyll is **not** present in carrots, sweet potatoes or tomatoes. ☒

B   Beta-carotene is present in carrots but **not** present in tomatoes. ☐

C   Both beta-carotene and lycopene are present in sweet potatoes. ☒

D   Lycopene is present in tomatoes but **not** present in carrots. ☐

E   Both carrots and tomatoes contain a pigment **other than**
    beta-carotene, chlorophyll and lycopene. ☒

P 4 5 9 4 3 A 0 9 3 2

(c) One of the pigments present in the vegetable extracts is not shown in the chromatogram. It appears as a very faint spot 1.3 cm above the starting line.

Calculate its R_f value using the expression

$$R_f = \frac{\text{distance travelled by pigment}}{\text{distance travelled by solvent}}$$

$$R_f = \frac{1.3}{6.0}$$
$$= 0.22$$

$R_f =$ ___0.22___

(d) Suggest a reason why there is a spot on the starting line in the chromatogram for sweet potatoes.

Does not dissolve / is insoluble in the solvent

(Total for Question 5 = 9 marks)

1.12

1.10

BLANK PAGE

6 Hydrogen chloride is formed in the reaction between hydrogen and chlorine.
The equation for the reaction is

$$H_2 + Cl_2 \rightarrow 2HCl$$
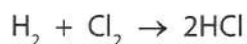
(a) Each molecule in this equation contains the same type of bonding.

Name this type of bonding.

covalent

(b) The bonding in a hydrogen molecule is strong.

Explain why the boiling point of hydrogen is low.

• Weak intermolecular forces

∴ Little energy required to overcome forces

(c) Explain how the two atoms in a chlorine molecule are held together.

Attraction between shared pair of electrons and

nuclei of both atoms

(d) Draw a dot and cross diagram to show the bonding in a hydrogen chloride molecule.

Show only the outer electrons in each atom.

H ×̇ C̈l ̤
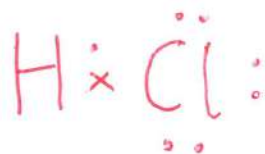
(e) Hydrogen chloride gas dissolves in water to form solution A.

Hydrogen chloride gas dissolves in methylbenzene to form solution B.

A teacher adds a piece of magnesium ribbon to each solution.

Explain why she observes effervescence with solution A but not with solution B.

(3)

• Effervescence due to hydrogen
• Solution A contains H^+
• Solution B does not contain H^+

(Total for Question 6 = 10 marks)

2.3,

7 The table shows the displayed formulae of some organic compounds.

A	B	C
H—C—H with H above and H below	H—C=C—C—H (H,H,H top, H bottom)	H—C—C—C—H (H,H,H top; H,H,H bottom)

D	E	F
H—C—C—C—C—H (H,H,H,H top; H,H,H,H bottom)	H—C—C=C—C—H (H,H,H,H top; H,H bottom)	ring structure

(a) Explain why all of these compounds are described as hydrocarbons.

(2)

4.01 contain hydrogen and carbon only

(b) Why are B and E described as unsaturated?

(1)

4.25 Oouble bond

(c) Which letter represents the first member of the homologous series of alkanes?

(1)

4.03 A

(d) Which letters represent compounds that have the empirical formula CH_2?

(2)

4.02 B, E, F

(e) Compound F has the same general formula as an alkene.

Why does F **not** decolourise bromine water?

(1)

.... Has   no   double   bond ....

....

(f) One of the compounds in the table reacts with bromine to form G, a compound with the composition by mass C = 22.2%, H = 3.7%, Br = 74.1%.

(i) Show, by calculation, that the empirical formula of G is C_2H_4Br

(3)

$$
\begin{array}{ccc}
C & H & Br \\
\dfrac{22.2}{12} & \dfrac{3.7}{1} & \dfrac{74.1}{80} \\[2mm]
\dfrac{1.85}{0.93} & \dfrac{3.7}{0.93} & \dfrac{0.93}{0.93} \\[2mm]
2 \quad : & 4 \quad : & 1
\end{array}
$$

(ii) The relative formula mass of G is 216

Deduce the molecular formula of G.

(2)

$Mr = (2\times12) + (4\times1) + (80\times1)$

$= 108$

$\dfrac{216}{108} = 2$

$C_4H_8Br_2$

molecular formula .... $C_4H_8Br_2$ ....

(Total for Question 7 = 12 marks)

4.28

1.33

1.33

P 4 5 9 4 3 A 0 1 5 3 2

8 Neodymium is a metal used in powerful magnets.

(a) One stage in the extraction of neodymium from its ore is to heat neodymium fluoride with calcium.

The table shows the melting points of the substances in this stage of the extraction.

Melting point in °C			
calcium	calcium fluoride	neodymium	neodymium fluoride
850	1418	1024	1410

(i) Balance the equation for this reaction.

$$\underline{2}\,NdF_3 + \underline{3}\,Ca \rightarrow \underline{2}\,Nd + \underline{3}\,CaF_2$$

1·25
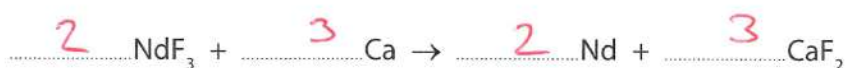
(ii) At one point in this extraction, the temperature of the reaction mixture is 1100 °C.

Which two substances are solids at this temperature?

calcium fluoride and neodymium fluoride

0.00

(iii) Suggest the most likely type of bonding present in neodymium fluoride.

Ionic

1.42

(iv) Neodymium reacts with oxygen to form neodymium oxide.

Suggest the formula of neodymium oxide.

Nd_2O_3

1.39

(b) The diagram shows the particles in neodymium
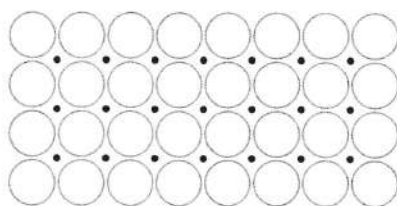
Key
◯ neodymium ion
· electron

Explain, with reference to the diagram, why neodymium is malleable and a good conductor of electricity.

(4)

• Ions ~~in~~ in layers slide over each other
• Delocalised electrons can move

(Total for Question 8 = 8 marks)

1.54

9 A student investigates the reactions between acids and alkalis. He uses this apparatus to measure the temperature change in the reaction between dilute hydrochloric acid (HCl) and aqueous sodium hydroxide (NaOH).
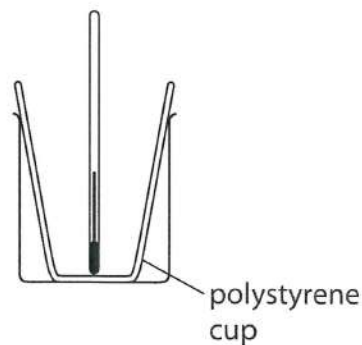
polystyrene
cup

This is his method.

- add 25 cm³ of dilute hydrochloric acid to the polystyrene cup and record the steady temperature

- add some aqueous sodium hydroxide and stir the mixture

- record the maximum temperature of the mixture

The student repeats the experiment using different volumes of aqueous sodium hydroxide.

(a) What is the advantage of using a polystyrene cup rather than a glass beaker?

(1)

3.02

Insulator / reduces heat loss

(b) These are the thermometer readings from one experiment.
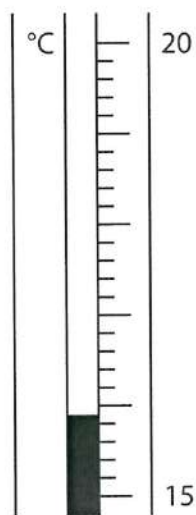
before adding
aqueous sodium hydroxide
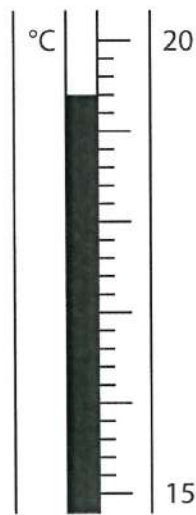
after adding
aqueous sodium hydroxide

Use these readings to complete the table.

(3)

|	
temperature in °C after adding aqueous sodium hydroxide	19.40
temperature in °C before adding aqueous sodium hydroxide	15.90
temperature change in °C	3.50

3.0?

P 4 5 9 4 3 A 0 1 9 3 2

(c) The table shows the results of some experiments.

The initial temperature of both solutions in all the experiments is 17.6 °C.

Volume of aqueous sodium hydroxide added in cm³	Temperature of mixture in °C
0.0	17.6
5.0	19.7
10.0	21.6
15.0	23.6
20.0	23.8
25.0	23.0
30.0	22.2

(i) Plot these results on the grid. Draw a straight line of best fit through the first four points, and another straight line of best fit through the last three points. Extend both lines so that they cross each other.

3.02

Temperature in °C

Volume of aqueous sodium hydroxide in cm³

P 4 5 9 4 3 A 0 2 0 3 2
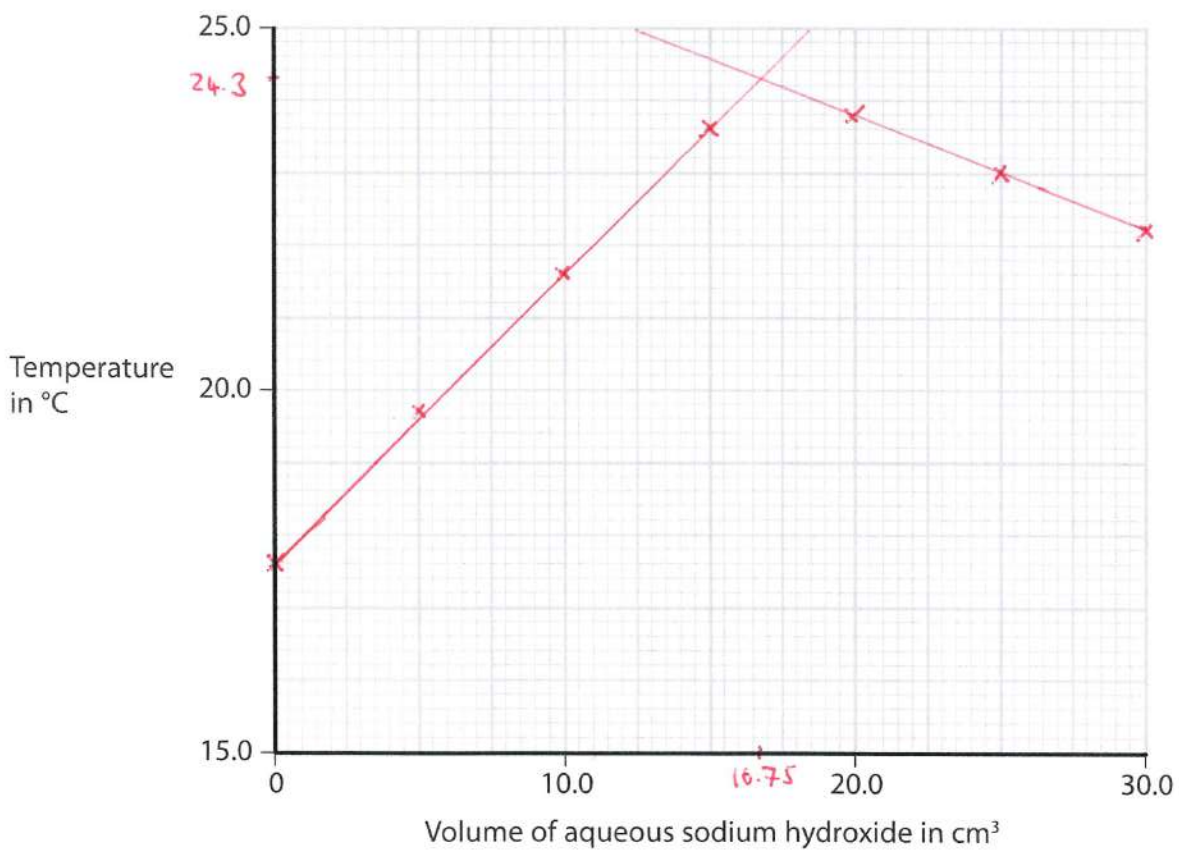
(ii) For the point where the lines cross, write down

(2)

the temperature of the mixture = 24.3 (±0.1) °C

the volume of aqueous sodium hydroxide = 16.75 (±0.25) cm³ 3.02

(d) In a similar experiment, using a different acid and alkali, the student records these results.

volume of dilute sulfuric acid = 25.0 cm³

volume of aqueous potassium hydroxide = 22.7 cm³

initial temperature of each solution = 18.9 °C

final temperature of mixture = 24.7 °C

Calculate the heat energy change during this reaction using this equation.

heat energy change = mass × 4.2 × temperature change

3.03

Assume that 1.0 cm³ of each solution has a mass of 1.0 g.

(3)

$$Q = 47.7 \times 4.2 \times (24.7 - 18.9)$$
$$Q = 1200 J$$

heat energy change = 1200 J

(Total for Question 9 = 13 marks)

10 Sodium thiosulfate solution and dilute hydrochloric acid react together slowly to form a precipitate of sulfur. This precipitate eventually makes the mixture go cloudy.

A student uses this method.

- place 20 cm³ of sodium thiosulfate solution and 20 cm³ of water in a conical flask

- add 10 cm³ of dilute hydrochloric acid to the flask

- place the flask on a piece of paper marked with a black ✗

- time how long it takes before the ✗ can no longer be seen

(a) The equation for the reaction is

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + S(s) + SO_2(g)$$
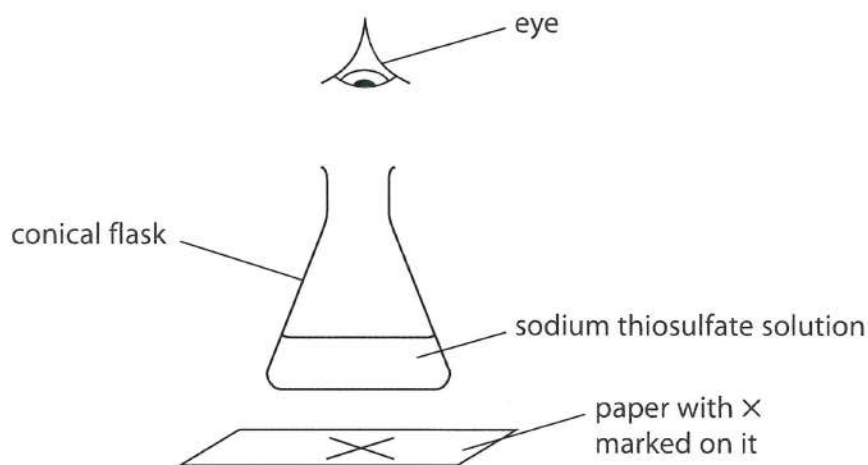
Before starting her experiments, the student considers the risk to her of sulfur dioxide escaping from the flask. She uses this information.

concentration of sodium thiosulfate solution = 0.300 mol/dm³

volume of sodium thiosulfate solution = 20 cm³

volume of water = 20 cm³

volume of hydrochloric acid = 10 cm³

(i) Calculate the mass of sulfur dioxide formed in this experiment.
The hydrochloric acid is in excess.

$n\ (Na_2S_2O_3) = \dfrac{0.300 \times 20}{1000}$

$= 0.006$

$m(SO_2) = 64 \times 0.006$

$= 0.38g$

$Mr\ (SO_2) = 32 + (2 \times 16)$

$= 64$

mass of sulfur dioxide formed = ...0.38........ g

(ii) The solubility of sulfur dioxide at room temperature is 100 g/dm³.

Use this additional information to explain whether any sulfur dioxide gas escapes from the flask.

Mass SO_2 in $1 dm^3 = \dfrac{0.384 \times 1000}{50}$ • volume of solvent is 50cm³ which

OR   would dissolve

$= 7.68g$ $\dfrac{100}{20} = 5g$ $0.384 < 5$

$7.68 < 100$

∴ No SO_2 escapes   ∴ No SO_2 escapes

(b) At what point in the experiment should the student have started a timer?

AS HCL added

(c) She repeats the experiment using the same volumes and concentrations of solutions, but at different temperatures. The graph shows her results.
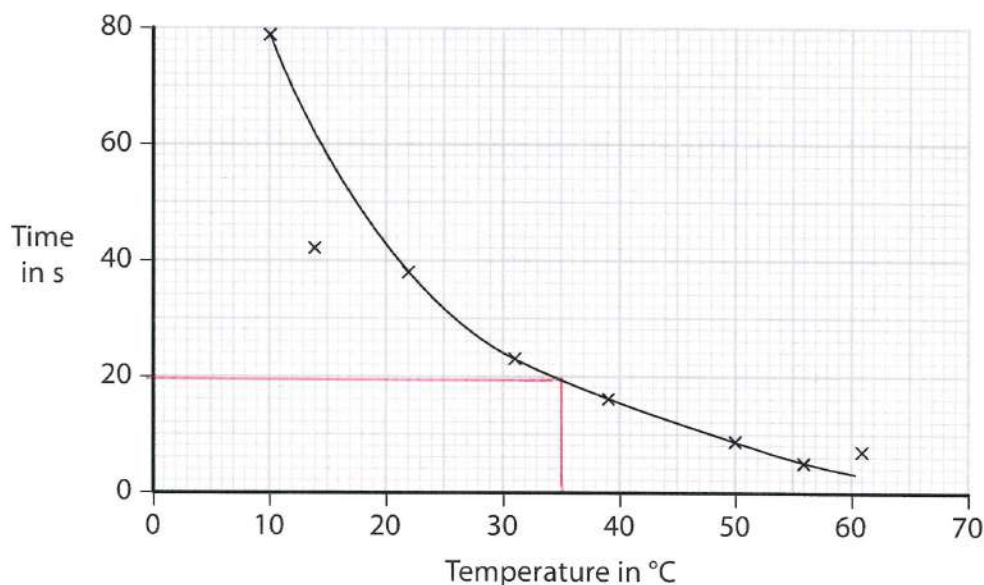
(i) The result at (14, 42) is anomalous.

Explain one mistake the student may have made to cause this anomalous result.

• Timer started too late OR

• Thermometer / timer read incorrectly

(ii) Use the graph to find the time taken for the X to be no longer seen at 35 °C.

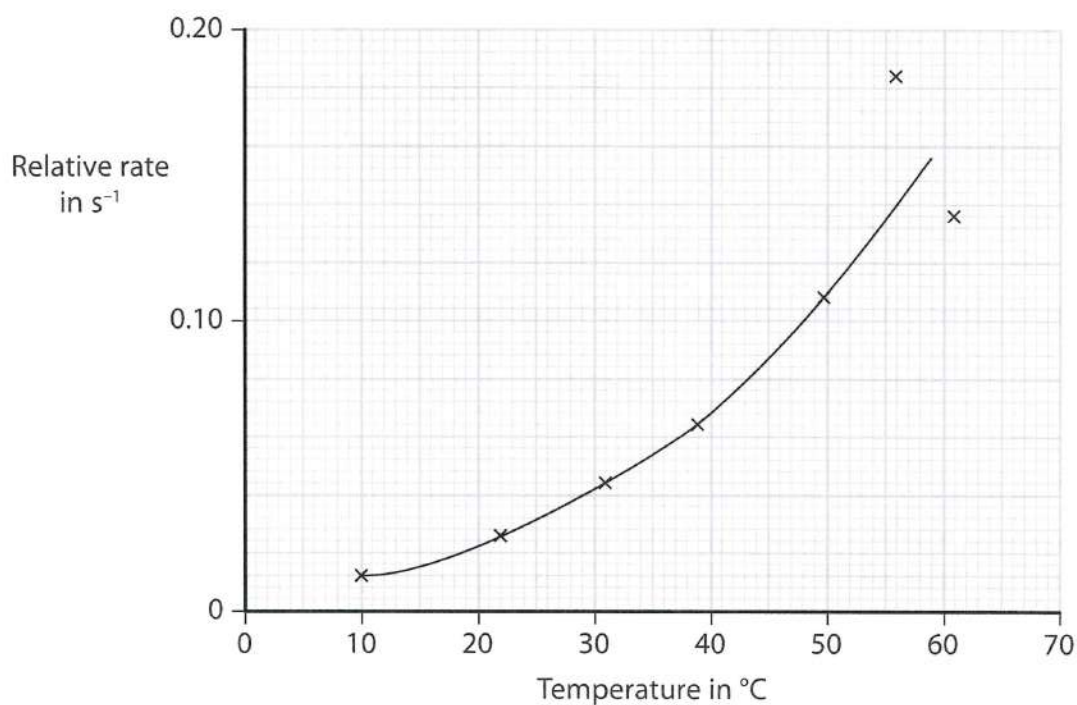19.5   (19-20)

P 4 5 9 4 3 A 0 2 3 3 2

(d) The student repeats the experiments using nitric acid in place of hydrochloric acid.
She records the times for the × to no longer be seen, then uses the times to
calculate the rate of reaction at each temperature.
The graph shows the results she plots.

(i) Suggest two reasons why the results are least accurate at higher temperatures.

(2)

area
3.08

1 .Times are short

2 • Heat loss greater

P 4 5 9 4 3 A 0 2 4 3 2

(ii) The student wrote this explanation for the shape of the graph.

As the temperature increases, the rate of reaction increases. This is because there are more frequent collisions between particles of reactants.

Use the particle collision theory to explain another more important reason for the increase in reaction rate.

(2)

3.11

- More collisions greater than activation energy
- ∴, More successful collisions per second

(e) Another student uses the same reaction to investigate the effect of changing the concentration of the sodium thiosulfate solution on the rate of reaction.

Give three variables that the student must control in this investigation to obtain valid results.

ANY 3

(3)

3.10

1 · concentration of acid

· volume of acid

2 · volume of Sodium thiosulfate

· Temperature

3

(Total for Question 10 = 15 marks)

11 The flow diagram shows how a fertiliser is manufactured from raw materials.

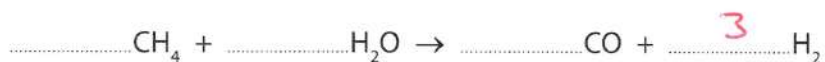| air natural gas water	carbon dioxide hydrogen nitrogen oxygen	ammonia	nitric acid	ammonium nitrate
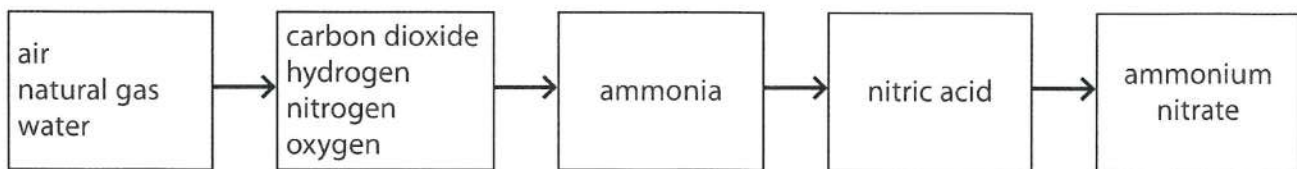
The hydrogen needed is formed in two reactions.

(a) Reaction 1 occurs between steam and methane in natural gas.

Balance the equation for this reaction.

1.25

$$\ldots\ldots CH_4 + \ldots\ldots H_2O \rightarrow \ldots\ldots CO + \quad 3 \quad H_2$$

(b) The equation for reaction 2 is
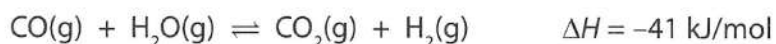
$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g) \qquad \Delta H = -41 \text{ kJ/mol}$$

(i) Assuming that this reaction reaches equilibrium, explain what happens to the yield of hydrogen if the reaction is carried out at a higher pressure but at the same temperature.

3.22C

- Equal numbers of molecules on each side
∴ ~~Must~~ NO effect

(ii) Assuming that this reaction reaches equilibrium, explain what happens to the yield of hydrogen if the reaction is carried out at a higher temperature but at the same pressure.

3.22C

- Forward reaction exothermic, equilibrium shifts to left as temp increases
∴ Yield decreases

(c) Reaction 2 can be represented on an energy profile.
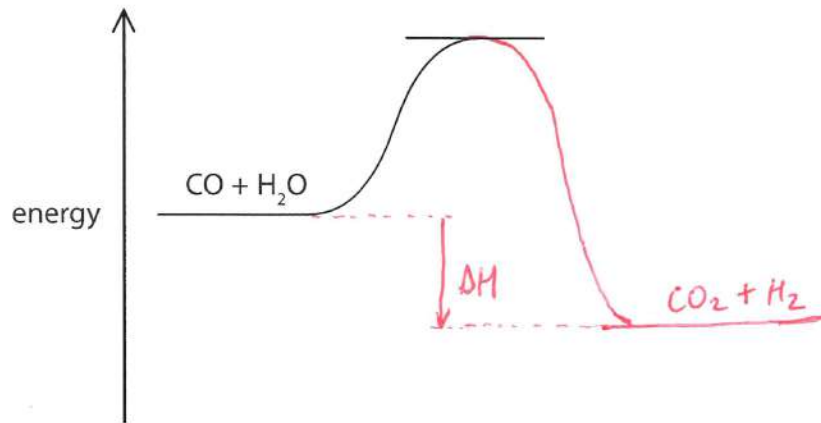
(i) Complete the profile by showing the products of the reaction and the enthalpy change for the reaction.

(2)

(ii) Reaction 2 is carried out using an iron oxide catalyst.

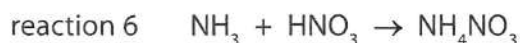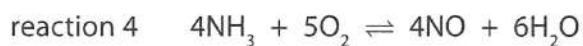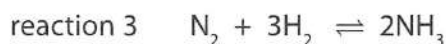State the effect, if any, of using a catalyst on the enthalpy change for the reaction.

(1)

NO effect

(iii) Explain how a catalyst increases the rate of a reaction.

(2)

· Provides alternative pathway
· Lower activation energy

Turn over ▶

(d) The equations for some other reactions used in the manufacture of ammonium nitrate are

reaction 3 $N_2 + 3H_2 \rightleftharpoons 2NH_3$

reaction 4 $4NH_3 + 5O_2 \rightleftharpoons 4NO + 6H_2O$

reaction 5 $2NO_2 \rightleftharpoons N_2O_4$

reaction 6 $NH_3 + HNO_3 \rightarrow NH_4NO_3$

Explain which two of these are redox reactions.

2.20

3, 4

• 3, gain of hydrogen
• 4, gain of oxygen

(e) The manufacturer produces a batch of 34 kg of ammonia.

Calculate the maximum mass of ammonium nitrate that can be made from this mass of ammonia, using reaction 6 in part (d).

Give a unit for your answer.

1.28

$n(NH_3) = \dfrac{34 \times 1000}{17}$

$= 2000\,mol$

$Mr\,(NH_4NO_3) = 80$

$Mass\,(NH_4NO_3) = 80 \times 2000$

$= 160000g / 160\,kg$

maximum mass of ammonium nitrate = ...160......... unit .....kg.....

(Total for Question 11 = 15 marks)

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12 The production of polymers from crude oil involves several processes, including

- fractional distillation
- cracking
- purification
- polymerisation

(a) Three of the fractions obtained from fractional distillation are fuel oil, gasoline and kerosene.

(i) Identify which of these fractions has the darkest colour.

4.10

fuel oil

(ii) Identify which of these fractions has the highest boiling point.

4.10

fuel oil

(iii) Identify which of these fractions contains molecules with the fewest carbon atoms.

4.10

gasoline

(b) Cracking involves heating some of the fractions to about 650 °C.

(i) Name a catalyst used in industry for cracking.

4.17

alumina / silica

(ii) One reaction that occurs in cracking involves the conversion of one molecule of hexadecane into one molecule of octane and two molecules of an alkene.

Complete the equation for this reaction.

1.25

$$C_{16}H_{34} \rightarrow C_8H_{18} + \quad 2C_4H_8$$

(iii) Give three reasons why cracking is carried out.

- Over supply of long-chain hydrocarbons
- High demand for short-chain hydrocarbons
- Alkenes used to make polymers

4.18

(c) One of the compounds sometimes present in crude oil has the formula $C_6H_{12}S$
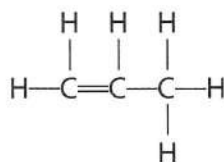
Explain why it is important to remove this compound from a fuel.

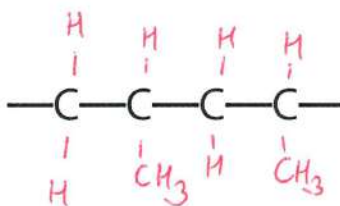- Forms sulfur dioxide
- Causes problems, eg. acid rain, toxic

4.16

(d) One compound obtained from crude oil is used as a monomer in polymerisation. It has the displayed formula

```
      H   H   H
      |   |   |
  H—C=C—C—H
              |
              H
```

Complete the following structure to show a part of the polymer formed from this monomer.

```
    H       H   H   H
    |       |   |   |
  —C—C—C—C—
    |       |   |   |
    H     CH₃  H  CH₃
```

4.46

(Total for Question 12 = 13 marks)

TOTAL FOR PAPER = 120 MARKS

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