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CHEMISTRY
STANDARD LEVEL
PAPER 2

Candidate session number

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Tuesday 8 May 2012 (afternoon)

1 hour 15 minutes

Examination code

2	2	1	2	–	6	1	1	1

INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer one question.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- A clean copy of the ***Chemistry*** *Data Booklet* is required for this paper.
- The maximum mark for this examination paper is *[50 marks]*.

21 pages

SECTION A

*Answer **all** questions. Write your answers in the boxes provided.*

1. Propanone reacts with bromine in acidic solution according to the following equation.

$$CH_3COCH_3(aq) + Br_2(aq) \xrightarrow{H^+(aq)} BrCH_2COCH_3(aq) + HBr(aq)$$

A student investigated the kinetics of this reaction using data logging equipment. Her data are shown below.

	A	B	C	D	E	F
1		**Initial concentration / mol dm^{-3}**				
2	**Experiment**	**[CH_3COCH_3] ± 0.001**	**[Br_2] ± 0.0001**	**[H^+] ± 0.0001**	**Time for colour to fade / s ± 1**	**Rate of reaction / mol dm^{-3} s^{-1}**
3	1	0.200	0.0100	0.0500	250	4.00×10^{-5}
4	2	0.400	0.0100	0.0500	125	8.00×10^{-5}
5	3	0.200	0.0200	0.0500	500	4.00×10^{-5}
6	4	0.200	0.0100	0.1000	125	8.00×10^{-5}
7	5	0.400	0.0050	0.0500	63	X
8						

(a) (i) Identify the reagent the student used to monitor the rate of reaction. *[1]*

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(ii) Calculate the rate of reaction for Experiment 5 and comment on the precision of your result. *[2]*

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(Question 1 continued)

(iii) Determine the percentage uncertainty in the calculated rate for Experiment 4. *[2]*

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(b) (i) Describe how the rate of reaction changes when the concentration of CH_3COCH_3 is doubled and explain this change on a molecular level. *[2]*

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(ii) The student suggested that H^+ acts as a catalyst in the reaction. Describe the effect of a catalyst on a chemical reaction. *[1]*

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(iii) Comment on whether or not this hypothesis is supported, with reference to the chemical equation and the experimental data. *[2]*

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2. In 1921 Thomas Midgley discovered that the addition of a lead compound could improve the combustion of hydrocarbons in automobile (car) engines. This was the beginning of the use of leaded gasoline (petrol).

The percentage composition, by mass, of the lead compound used by Midgley is shown below.

	Pb	**C**	**H**
Mass composition / %	64.052	29.703	6.245

(a) (i) Determine the empirical formula of the lead compound. *[3]*

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(ii) Leaded gasoline has been phased out because the lead(IV) oxide, PbO_2, produced as a side product in the combustion reaction, may cause brain damage in children.

0.01 mol of Midgley's lead compound produces 0.01 mol of lead(IV) oxide. Deduce the molecular formula of Midgley's compound. *[1]*

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(iii) Determine the equation for the complete combustion of Midgley's compound. *[2]*

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(This question continues on the following page)

(Question 2 continued)

(b) The combustion of unleaded gasoline still produces pollution with both local and global consequences. Identify **one** exhaust gas which causes local pollution and **one** exhaust gas which causes global pollution. *[2]*

Local pollutant:

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Global pollutant:

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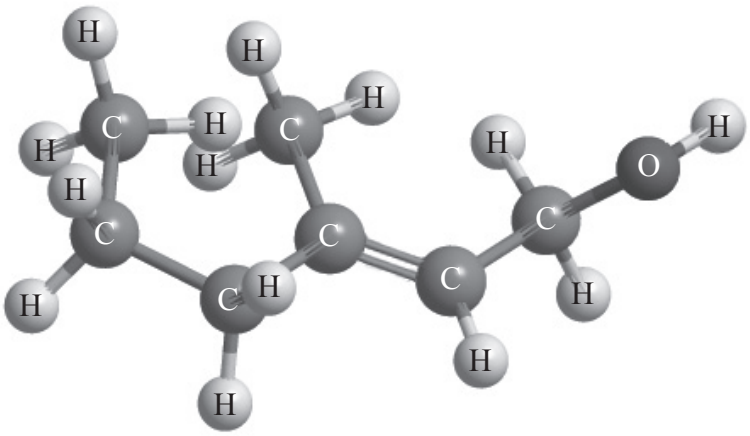
3. Compound **X** (shown below) is produced by bacteria living in human armpits and is thought to be partly responsible for unpleasant body smells.

(a) Bromine water can be used to test for the presence of one of the functional groups in **X**. Identify this functional group and describe the colour change observed. *[2]*



X

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(b) The other functional group changes when **X** is refluxed with acidified excess potassium dichromate(VI) to produce a compound **Y**.

(i) Identify the functional group present in **Y** but not in **X**. *[1]*

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(ii) State the type of reaction that **X** undergoes to form **Y**. *[1]*

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(This question continues on the following page)

(Question 3 continued)

(c) A different compound is produced if excess **X** is heated with acidified potassium dichromate(VI) and the product **Z** is distilled off as it forms.

(i) Identify the functional group present in **Z** but not in **X**. *[1]*

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(ii) Predict the order of increasing boiling point of the compounds **X**, **Y** and **Z** and explain your answer. *[3]*

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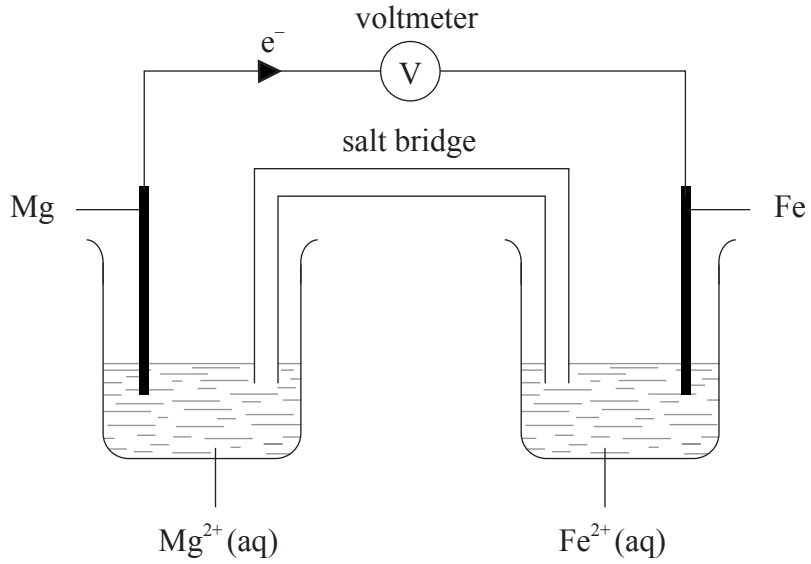
4. Chemical energy can be converted to electrical energy in the voltaic cell below.



(a) (i) State the electron arrangement of a magnesium atom. *[1]*

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(ii) State the half-equation which describes the change at the Mg electrode and deduce which metal is the positive electrode (cathode) of the cell. *[2]*

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(b) Deduce the equation for the overall reaction occurring in the cell. *[1]*

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SECTION B

*Answer **one** question. Write your answers in the boxes provided.*

5. Ethane, C_2H_6, and disilane, Si_2H_6, are both hydrides of group 4 elements with similar structures but with different chemical properties.

(a) (i) Deduce the Lewis (electron dot) structure for Si_2H_6 showing all valence electrons. *[1]*

(ii) State and explain the H–Si–H bond angle in Si_2H_6. *[2]*

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(iii) State which of the bonds, Si–H or C–H, is more polar. Explain your choice. *[2]*

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(Question 5 continued)

(iv) Predict, with an explanation, the polarity of the two molecules. *[2]*

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(v) Explain why disilane has a higher boiling point than ethane. *[2]*

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(b) Disilane undergoes complete oxidation to form silicon dioxide and water.

$$2Si_2H_6(g)+7O_2(g) \rightarrow 4SiO_2(s) + 6H_2O(l)$$

The standard enthalpy change for this reaction, $\Delta H^{\ominus} = -5520$ kJ.

(i) Calculate the standard enthalpy change, in kJ, for the corresponding combustion reaction of 2 moles of ethane, using Table 12 of the Data Booklet. *[1]*

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(This question continues on the following page)

(Question 5 continued)

(ii) Compare the structure and bonding in carbon dioxide and silicon dioxide. *[3]*

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(iii) Carbon dioxide and silicon dioxide can both be described as acidic oxides. Describe the pH changes that occur when each is added to separate samples of water. *[2]*

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(c) The different properties of the hydrides can be accounted for by the different bond enthalpies of the covalent bonds formed by silicon and carbon.

(i) Define the term *average bond enthalpy*. *[2]*

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(Question 5 continued)

(ii) Disilane reacts with hydrogen to produce silane, SiH_4.

$$Si_2H_6(g) + H_2(g) \rightarrow 2SiH_4(g)$$

Use values from Table 10 of the Data Booklet to calculate the enthalpy change, $\Delta H^{\ominus}$, for this reaction. *[3]*

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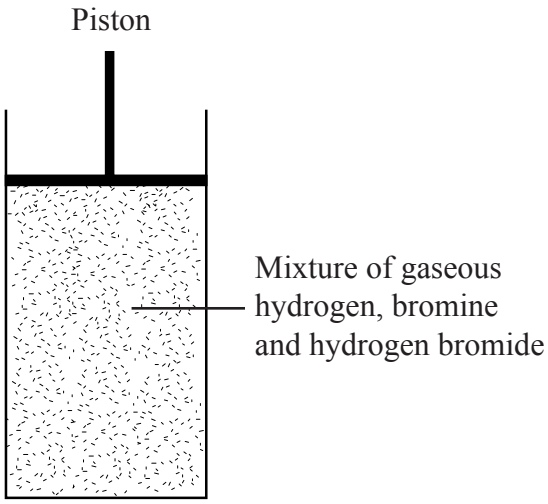
6. Consider the equilibrium system involving bromine and its hydride.



(a) State an equation to represent the equilibrium with $H_2(g)$ and $Br_2(g)$ as reactants. *[1]*

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(b) (i) Predict what happens to the position of equilibrium if a small amount of hydrogen is introduced. *[1]*

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(ii) State and explain the effect of increasing the pressure on the position of equilibrium. *[2]*

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(Question 6 continued)

(c) (i) Deduce the equilibrium constant expression, K_c, for the equilibrium in (a). *[1]*

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(ii) State the effect of increasing $[H_2]$ on the value of K_c. *[1]*

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(d) Hydrogen bromide forms a strong acid when dissolved in water whereas hydrogen fluoride forms a weak acid. Distinguish between the terms *strong acid* **and** *weak acid*. State equations to describe the dissociation of each acid in aqueous solution. *[3]*

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(Question 6 continued)

(e) When bromine dissolves in water, 1 % of the original bromine molecules react according to the following equation.

$$Br_2(aq) + H_2O(l) \rightleftharpoons HOBr(aq) + HBr(aq)$$

(i) Deduce the oxidation numbers of bromine in the reactant **and** products. *[2]*

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(ii) Explain the changes in the oxidation numbers of bromine. *[1]*

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(iii) Estimate the magnitude of K_c for this reaction. Choose your value from the following options: *[1]*

$K_c = 0$ $K_c < 1$ $K_c = 1$ $K_c > 1$

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(This question continues on the following page)

(Question 6 continued)

(iv) State and explain what happens to the equilibrium, in (e), when aqueous sodium hydroxide is added to the reaction solution at equilibrium. *[2]*

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(f) Fluorine reacts with water to produce oxygen.

$$2F_2(g) + 2H_2O(l) \rightarrow 4HF(g) + O_2(g)$$

(i) Identify the oxidizing agent in the reaction. *[1]*

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(ii) 100 cm^3 of fluorine gas is added to water. Calculate the volume of oxygen produced at the same temperature and pressure. *[1]*

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(Question 6 continued)

(iii) The reactions between the halogens and water show that fluorine is more reactive than bromine. Explain why, on an atomic level, fluorine is the more reactive element. *[3]*

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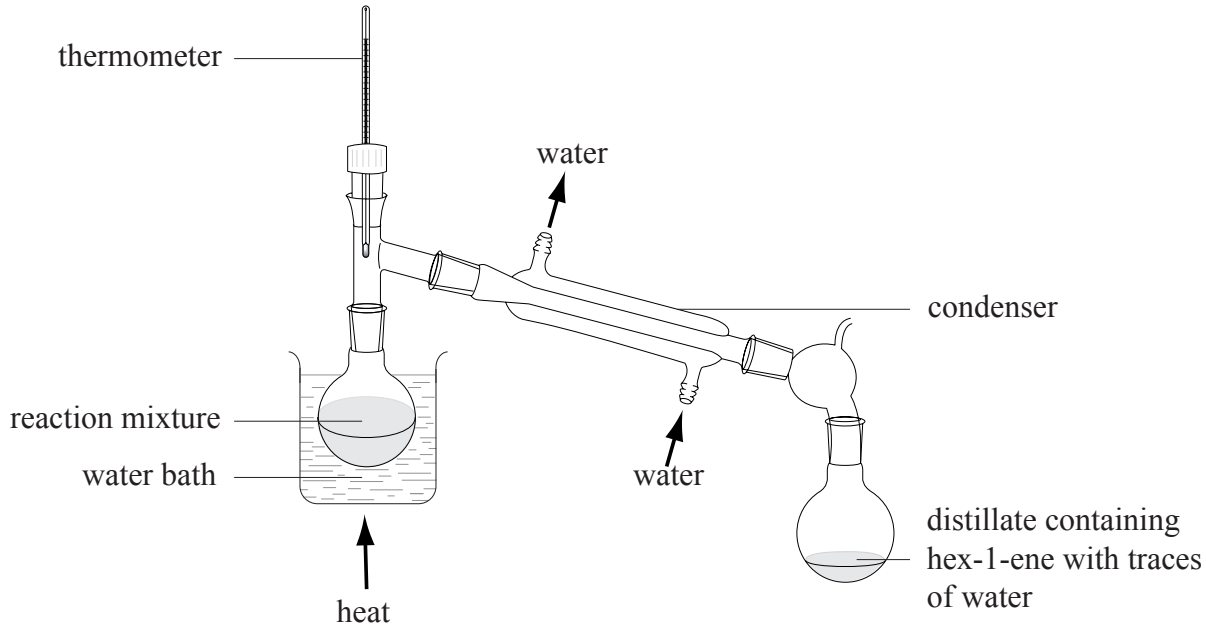
7. A student prepared hex-1-ene, C_6H_{12}, from hexan-1-ol, $C_6H_{13}OH$, by a dehydration reaction.

$$C_6H_{13}OH\,(l) \rightarrow C_6H_{12}\,(l) + H_2O\,(l)$$

The apparatus for this preparation is shown below. The reaction mixture contains 5.00 g of hexan-1-ol and an excess of concentrated sulfuric acid, which removes the water from the organic compound.



The distillate was dried to obtain 2.62 g of hex-1-ene.

(a) (i) Determine the amount, in mol, of hexan-1-ol present in the reaction mixture. *[2]*

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(Question 7 continued)

(ii) Calculate the percentage yield of hex-1-ene produced. *[2]*

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(iii) Another student repeated the experiment and reported a yield of 5.24 g of organic product. Comment on this result. *[2]*

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(b) Hex-1-ene can be converted to hexane in a single step.

(i) State the reagent and conditions needed and draw the structural formula of the product. *[2]*

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(This question continues on the following page)

(Question 7 continued)

(ii) Deduce the names of three isomers of hexane. *[3]*

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(iii) Identify the compound with the molecular formula C_6H_{14} which has the highest boiling point and explain your choice. *[3]*

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(iv) The conversion of carbon-carbon double bonds to carbon-carbon single bonds is an important stage in the synthesis of a commercial product. Identify this commercial product. *[1]*

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(This question continues on the following page)

(Question 7 continued)

(c) (i) Hexane reacts with chlorine to form different products. The reactions can be represented by the following equation, where R is an alkyl chain.

$$R–H + Cl_2 \rightarrow R–Cl + HCl$$

Describe the stepwise mechanism by giving **one** equation for each step and state the essential condition in the initiation step. *[4]*

Initiation:

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Essential condition:

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Propagation:

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Termination:

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(ii) Deduce the number of straight-chain structural isomers produced with the molecular formula $C_6H_{13}Cl$. *[1]*

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