Edexcel

A2

Chemistry

Practice Unit Test 4

PHILIP ALLAN
UPDATES

Practice Unit Test 4

Time allowed: 1 hour 40 minutes

Material required for examination: *Data Booklet*

Answer *all* questions.

In questions indicated by an asterisk, quality of written communication will be taken into account.

The total for the paper is 90 marks.

Use the periodic table printed at the back of the textbook (page xxx).

Section A

You should aim to spend no more than 30 minutes on this section.

For each question, select one answer from A to D and put a cross in the box. If you change your mind, put a horizontal line through the cross and then mark your new answer with a cross.

1 What is the concentration of OH^- in mol dm^{-3} ions in an aqueous solution of pH 3.0?

- ☐ **A** zero
- ☐ **B** 1×10^{-3}
- ☐ **C** 1×10^{-7}
- ☐ **D** 1×10^{-11}

Use this space for any rough working. Anything you write in this space will gain no credit.

2 The conjugate base of the OH^- ion is:

- ☐ **A** O^{2-}
- ☐ **B** H_2O
- ☐ **C** H_3O^+
- ☐ **D** NaOH

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3 Hydrogen can be manufactured from carbon and steam:

$$C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g) \quad \Delta H = +131\ kJ\ mol^{-1}$$

The equilibrium yield of hydrogen can be increased by:

- ☐ **A** adding more carbon
- ☐ **B** increasing the pressure
- ☐ **C** increasing the temperature
- ☐ **D** adding a catalyst

4 Which of the following will have the greatest positive ΔS_{system}?

- ☐ **A** $NaCl(s) + aq \rightarrow Na^+(aq) + Cl^-(aq)$
- ☐ **B** $KCl(s) + aq \rightarrow K^+(aq) + Cl^-(aq)$
- ☐ **C** $MgCl_2(s) + aq \rightarrow Mg^{2+}(aq) + 2Cl^-(aq)$
- ☐ **D** $CaCl_2(aq) + aq \rightarrow Ca^{2+}(aq) + 2Cl^-(aq)$

Use the information below to answer questions 5 and 6.

$$Fe_3O_4(s) + 4H_2(g) \rightleftharpoons 3Fe(s) + 4H_2O(g) \quad \Delta H^{\ominus} = +150\ kJ\ mol^{-1}$$
$$\Delta S^{\ominus}_{system} = +151\ J\ K^{-1}\ mol^{-1}$$

	$H_2(g)$	$Fe(s)$	$H_2O(g)$
$\Delta H_f^{\ominus}$/ kJ mol^{-1}	0	0	−242
$S^{\ominus}$/J K^{-1} mol^{-1}	+131	27.0	+190

5 The standard enthalpy of formation of $Fe_3O_4(s)$ in kJ mol^{-1} is:

- ☐ **A** +92
- ☐ **B** −392
- ☐ **C** −818
- ☐ **D** −1118

6 The standard entropy of $Fe_3O_4(s)$ in J K^{-1} mol^{-1} is:

- ☐ **A** −166
- ☐ **B** +166
- ☐ **C** +183
- ☐ **D** +468

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7 Iodate(V) ions are reduced by iodide ions in acid solution:

$$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$$

The rate equation for this reaction is rate = $k[IO_3^-][I^-][H^+]^2$. Halving both the $[IO_3^-]$ and the $[I^-]$ and doubling $[H^+]$ will cause the rate to:

- ☐ **A** increase by a factor of 4
- ☐ **B** increase by a factor of 2
- ☐ **C** halve
- ☐ **D** stay the same

Questions 8 to 10 refer to the titration curve obtained when 40 cm^3 of a 0.100 mol dm^{-3} solution of sodium hydroxide is added in small portions to 20 cm^3 of a 0.100 mol dm^{-3} solution of a weak acid that has an acid dissociation constant, K_a, = 1.0×10^{-5} mol dm^{-3}.

8 The pH at the start is approximately:

- ☐ **A** 1
- ☐ **B** 3
- ☐ **C** 11
- ☐ **D** 13

9 The pH after 10 cm^3 of sodium hydroxide has been added is:

- ☐ **A** 3
- ☐ **B** 4
- ☐ **C** 5
- ☐ **D** 6

10 The pH when 20 cm^3 has been added is approximately 9. Which of the following indicators would be suitable for this titration? (You may use your data booklet.)

- ☐ **A** methyl orange
- ☐ **B** bromocresol green
- ☐ **C** thymol blue
- ☐ **D** alizarin yellow

Use the data below to answer questions 11 to 13.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

The system is at equilibrium at a temperature of 700°C and a total pressure of 2.0 atm.

Substance	Number of moles at equilibrium
$CH_4(g)$	0.10
$H_2O(g)$	0.10
$CO(g)$	0.0040
$H_2(g)$	0.0030

11 The units for the equilibrium constant, K_p, are:

- ☐ **A** none
- ☐ **B** atm
- ☐ **C** atm^2
- ☐ **D** atm^{-2}

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12 The mole fraction of hydrogen is

- ☐ **A** 0.003/0.213
- ☐ **B** 0.003/0.207
- ☐ **C** 0.009/0.213
- ☐ **D** 0.009/0.207

13 The numerical value of the equilibrium constant is:

- ☐ **A** 1.0×10^{-6}
- ☐ **B** 2.5×10^{-7}
- ☐ **C** 0.0012
- ☐ **D** 1.0×10^{6}

Use this space for any rough working. Anything you write in this space will gain no credit.

14 Which would **not** react with iodine and alkali?

- ☐ **A** butan-2-one, $CH_3COCH_2CH_3$
- ☐ **B** propan-2-ol, $CH_3CH(OH)CH_3$
- ☐ **C** 3-methylbutan-2-ol, $(CH_3)_2CHCH(OH)CH_3$
- ☐ **D** 1-hydroxybutan-2-one, $CH_2(OH)COCH_2CH_3$

15 Which does **not** have intermolecular hydrogen bonding?

- ☐ **A** propanone, CH_3COCH_3
- ☐ **B** ethanoic acid, CH_3COOH
- ☐ **C** 1-hydroxybutan-2-one, $CH_2(OH)COCH_2CH_3$
- ☐ **D** ethanol, C_2H_5OH

16 Which does **not** form hydrogen bonds with water?

- ☐ **A** propanone, CH_3COCH_3
- ☐ **B** ethoxyethane, $C_2H_5OC_2H_5$
- ☐ **C** methanoic acid, HCOOH
- ☐ **D** methanol, CH_3OH

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17 The product of the nucleophilic addition of cyanide ions to ethanal:

- ☐ **A** is a racemic mixture
- ☐ **B** is the + stereoisomer
- ☐ **C** is a *Z*-isomer
- ☐ **D** depends on the solvent used

18 The number of stereoisomers of $CH_3CH(OH)CH{=}CHCH_3$ is:

- ☐ **A** 1
- ☐ **B** 2
- ☐ **C** 4
- ☐ **D** 6

19 An isomer of C_4H_8O has a peak in its mass spectrum at $m/e = 57$, an infrared peak at 1720 cm^{-1} and has an NMR spectrum showing 3 peaks with intensities in the ratio 3:3:2. The isomer is:

- ☐ **A** $CH_2{=}C(CH_3)CH_2OH$
- ☐ **B** $CH_3COCH_2CH_3$
- ☐ **C** $CHOCH(CH_3)_2$
- ☐ **D** $CH_2{=}CHCH_2CH_2OH$

20 An isomer of $C_4H_5O_2Cl$ reacts with an alcohol to give an ester, gives a yellow precipitate with 2,4-dinitrophenylhydrazine, but has no effect on warm acidified potassium dichromate(VI). The isomer is:

- ☐ **A** CH_3COCH_2COCl
- ☐ **B** $CHOCH_2CH_2COCl$
- ☐ **C** $CHOCH{=}C(OH)CH_2Cl$
- ☐ **D** $CH_2OHCH{=}C(Cl)COOH$

Total: 20 marks

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Section B

Answer all the questions.

21 Methanol is a potential liquid fuel. It can be made from carbon monoxide and hydrogen according to the reaction:

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

The conditions for this process are:

- a heterogeneous copper/zinc oxide catalyst
- 75 atm pressure
- temperature of 250°C

	CO(g)	H_2(g)	CH_3OH(g)
$S^{\ominus}$/J K^{-1} mol^{-1}	198	131	238
$\Delta H_f^{\ominus}$/ kJ mol^{-1}	–111	0	–201

a Write the expression for the equilibrium constant, K_p, for this reaction. **(1)**

b (i) What is meant by **heterogeneous** as applied to a catalyst? **(1)**

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***(ii)** Explain, in terms of energetics and collision theory, how a catalyst causes the rate of a reaction to increase. **(3)**

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c **(i)** Calculate the standard entropy change of the system. **(1)**

(ii) Calculate the standard enthalpy change of the reaction and hence the entropy change of the surroundings. **(3)**

(iii) Calculate the total entropy change and hence the value of the equilibrium constant, K_p, at 250°C. (The gas constant $R = 8.31\,J\,K^{-1}\,mol^{-1}$) **(3)**

(iv) Comment on the feasibility of this reaction at 250°C. **(1)**

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(v) Calculate the value of the equilibrium constant, K_p, at a temperature of 350°C. Assume that neither ΔH_r nor ΔS_{system} change in value as the temperature is increased from 250°C to 350°C. **(2)**

***d** Explain why a temperature of 250°C and a pressure of 75 atm is used in this manufacturing process. **(4)**

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e 1.00 mol of carbon monoxide and 2.00 mol of hydrogen were mixed in the presence of the catalyst at a temperature that was neither 250°C nor 350°C. The system was allowed to reach equilibrium at a total pressure of 100 atm. The equilibrium mixture contained 0.25 mol of carbon monoxide.

Calculate the value of the equilibrium constant, K_p, at the temperature of the experiment. Include the units in your answer. **(5)**

Total: 24 marks

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22 a The presence of an aldehyde is shown by positive results from reaction of the test solution with 2,4-dinitrophenylhydrazine and with Tollens' reagent. Ethanal is the only aldehyde that gives a positive result with a solution of iodine in alkali.

Draw the structural formula of the organic product of the reaction of ethanal with:

(i) 2,4-dinitrophenylhydrazine **(2)**

(ii) Tollens' reagent **(1)**

(iii) a solution of iodine in sodium hydroxide **(2)**

b Ethanal can be oxidised to ethanoic acid, CH_3COOH.

(i) A buffer solution of pH 5.00 was made from 100 cm^3 of a 0.500 mol dm^{-3} ethanoic acid and solid sodium ethanoate. Calculate the mass of sodium ethanoate required to produce this buffer solution.
(K_a for ethanoic acid = 1.74×10^{-5} mol dm^{-3}) **(5)**

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*(ii) Explain why the addition of a small quantity of $H^+(aq)$ ions to this solution hardly alters its pH. Include a relevant equation in your answer. (3)

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(iii) When a solution of ethanoic acid is titrated with sodium hydroxide solution, an indicator that changes pH in the range 8 to 10 must be used because solutions of the salt, sodium ethanoate, are alkaline. Write the equation that shows why a solution of ethanoate ions is alkaline. (1)

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c Organic acids, such as ethanoic acid, CH_3COOH, or the long-chain acid, $C_{17}H_{35}COOH$, react with esters under suitable conditions in a transesterification reaction.

(i) Explain, with an example involving ethanoic acid, what is meant by a transesterification reaction. (1)

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(ii) Explain how use is made of this type of reaction in the manufacture of low-fat spreads from vegetable oils. (2)

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d Some synthetic fibres are made from polyesters. Draw part of the structure of the biodegradable polyester that could be made from 2-hydroxypropanoic acid, $CH_3CH(OH)COOH$. Show two units. (2)

Total: 18 marks

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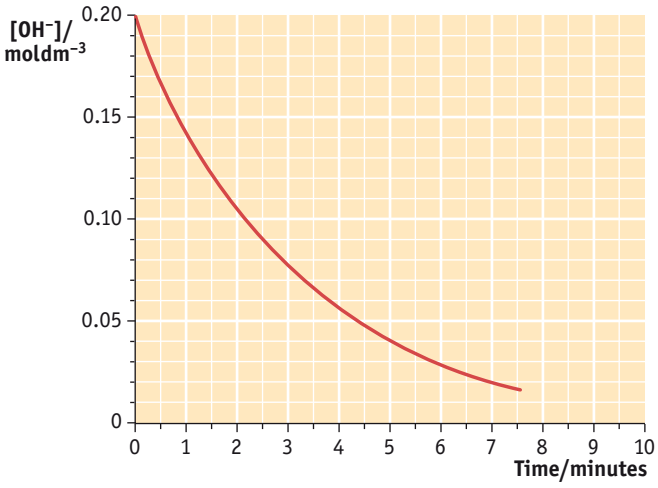
23 Aqueous sodium hydroxide reacts with 2-bromopropane to form propan-2-ol and sodium bromide. The kinetics of this reaction were studied by measuring the concentration of OH^- ions as a function of time. The graph below shows the results of an experiment using a solution that contained 0.20 mol dm^{-3} sodium hydroxide and excess 2-bromopropane.



a Use the graph to calculate two consecutive half-lives. State the order of the reaction. **(3)**

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b The reaction was repeated with the same amount of 2-bromopropane but with sodium hydroxide of concentration 0.40 mol dm^{-3}. The half-life was the same as when a 0.20 mol dm^{-3} solution was used. Use this information and that from (a) to deduce the rate equation for this reaction. **(2)**

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c Write a mechanism for this reaction that is consistent with the rate equation given in (b). **(3)**

Total: 8 marks

Section total: 50 marks

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Section C

24 Geraniol is the substance responsible for the distinctive smell of roses.

a Geraniol has the following percentage composition by mass: carbon 77.9, hydrogen 11.7, oxygen 10.4.

Calculate the empirical formula of geraniol and show that it is consistent with the molecular formula $C_{10}H_{18}O$. **(2)**

b From the following data, what can be deduced about geraniol?

(i) When mixed in the dark, 1 mol of geraniol reacts with 2 mol of bromine. **(1)**

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(ii) Geraniol gives off steamy fumes when added to phosphorus pentachloride. **(1)**

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(iii) The infrared spectrum has peaks at wave numbers:
1653 cm^{-1}, 2985 cm^{-1}, 3041 cm^{-1} and 3512 cm^{-1}. **(3)**

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c Geraniol can be oxidised to a compound **X** that is present in lemon-grass oil by warming with acidified potassium dichromate(VI) and distilling off the product as it is formed.

What can be deduced from the following?

(i) The mass spectrum of compound **X** has a molecular ion peak at $m/e = 152$. **(1)**

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(ii) Compound **X** reacts with 2,4-dinitrophenylhydrazine to give a yellow-orange precipitate. **(1)**

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(iii) Compound **X** has an NMR peak at δ 9.5. **(1)**

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(iv) What information about geraniol do the deductions from (c) (ii) and (c) (iii) suggest? **(1)**

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(v) Why must geraniol *not* be heated under reflux with acidified potassium dichromate(VI) in the preparation of compound **X**? **(1)**

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d Geraniol and compound X are derived from a dialkene, C_5H_8, which either has the formula, $CH_2{=}C(CH_3)CH{=}CH_2$ or $CH_2{=}CHCH_2CH{=}CH_2$. The dialkene has four peaks in its NMR spectrum, with peak areas in the ratio 3:2:2:1.

***(i)** State, with reasons, which of the two formulae is that of the dialkene. **(2)**

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(ii) State how the peak due to the hydrogen nuclei in the $=CH_2$ group in $CH_2{=}CHCH_2CH{=}CH_2$ is split. Justify your answer. **(1)**

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***(iii)** Explain why neither of the two dialkenes shows geometric isomerism. **(2)**

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***e** Compound **X** can be separated from unreacted geraniol and any other organic impurities by HPLC. Briefly describe the principles of HPLC. **(3)**

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Total: 20 marks

Paper total: 90 marks

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