Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	2	5	4	/	0	1	Signature	

Paper Reference(s)

6254/01

Edexcel GCE

Chemistry (Nuffield)

Advanced

Unit Test 4

Monday 18 June 2007 – Afternoon

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
3	
4	
Total	

Materials required for examination
Nil

Items included with question papers
Nil

A calculator may be used.

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and your signature.
Answer **ALL** the questions. Write your answers in the spaces provided in this question paper.
Final answers to calculations should be given to an appropriate number of significant figures.

Information for Candidates

A Periodic Table is printed on the back cover of this question paper.
The marks for the various parts of questions are shown in round brackets: e.g. **(2)**.
The total mark for this paper is 60. There are 16 pages in this paper. All blank pages are indicated.

Advice to Candidates

You are advised to show all steps in any calculations.
You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, taking into account your use of grammar, punctuation and spelling.

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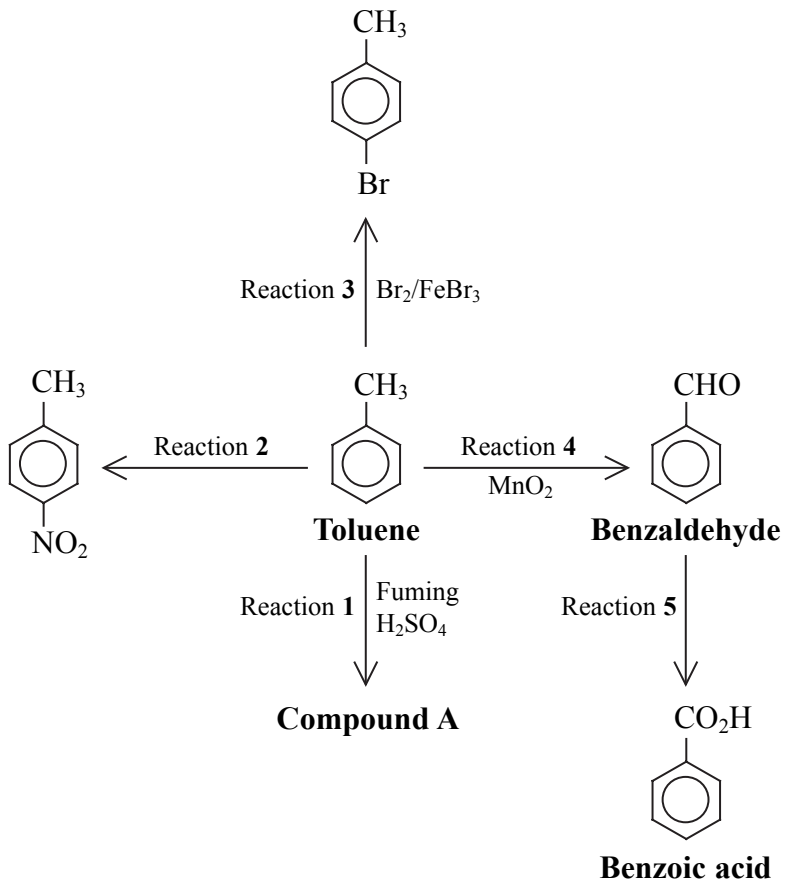
Answer ALL the questions. Write your answers in the spaces provided.

1. Toluene is the non-systematic name of an arene widely used in industry. Its formula is $C_6H_5CH_3$. Some of its reactions are summarised in the following diagram.



(a) (i) Give the systematic name of toluene.

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(1)

(ii) Draw a possible structural formula for **compound A**.

(1)

Leave blank

(b) (i) Name the TWO reagents needed for Reaction **2**.

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(2)

(ii) Give the formula of the attacking species in Reaction **2**.

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(1)

(c) (i) Give the reaction type and mechanism in Reaction **3**.

Reaction Type

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Mechanism

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(2)

(ii) Suggest why Reactions 1, 2 and 3 all take place under milder conditions than similar reactions involving benzene.

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(2)

(d) What type of reaction does toluene undergo in Reaction **4**?

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(1)

(e) Name the TWO reagents needed for Reaction **5**.

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(2)

Leave blank

(f) Describe a test to distinguish between benzaldehyde and benzoic acid. In each case describe the result you would expect to see.

Test

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Result with benzaldehyde

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Result with benzoic acid

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(3)

(Total 15 marks)

Q1

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2. In the presence of hydrogen ions, H^+, glucose, $C_6H_{12}O_6$, can be oxidised by a solution of potassium manganate(VII), $KMnO_4$, which is purple in colour.

A series of experiments was carried out to determine the rate of reaction and the results are shown below.

Experiment	Initial concentration of $C_6H_{12}O_6$ / mol dm^{-3}	Initial concentration of $KMnO_4$ / mol dm^{-3}	Initial concentration of H^+ / mol dm^{-3}	Rate of reaction / mol dm^{-3} s^{-1}
1	1.0	0.01	0.5	2.0×10^{-5}
2	1.0	0.005	0.5	1.0×10^{-5}
3	0.5	0.005	0.5	1.0×10^{-5}
4	1.0	0.02	1.0	8.0×10^{-5}

(a) Describe how the rate of this reaction may have been measured.

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(2)

(b) (i) Give the order of reaction with respect to each reactant. In the case of potassium manganate(VII) and hydrogen ions explain how you arrived at your answer.

Glucose .....

Potassium manganate(VII) .....

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Hydrogen ions .....

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(3)

Leave blank

(ii) Write the rate equation for this reaction.

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(1)

(iii) Using the data from **experiment 1**, calculate the rate constant for the reaction. Include the units of the rate constant in your final answer.

(2)

(c) Additional experiments were carried out to investigate the effect of temperature on the rate of reaction.

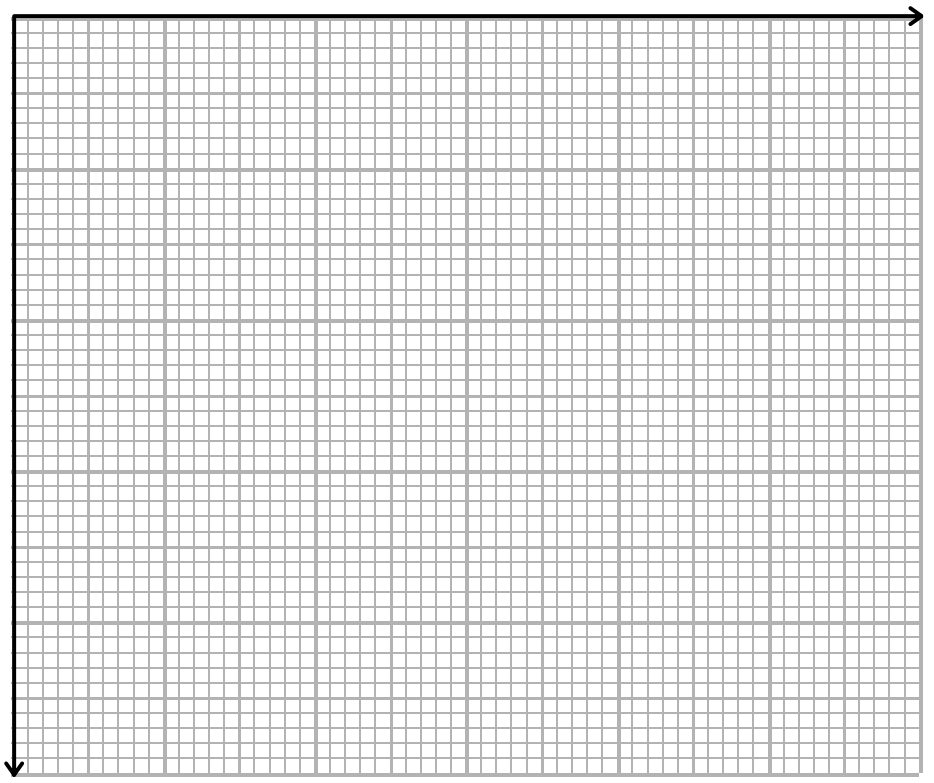
(i) Complete the missing data in the table below.

Temperature (T) / K	1/ temperature (1/T) / K^{-1}	Rate constant	ln (rate constant)
295	3.39×10^{-3}	2.88×10^{-3}	–5.85
305	3.28×10^{-3}	1.01×10^{-2}	–4.60
311		1.83×10^{-2}	
320	3.13×10^{-3}	4.98×10^{-2}	–3.00
333	3.00×10^{-3}	2.02×10^{-1}	–1.60

(1)

Leave blank

(ii) Plot a graph of ln (rate constant) on the vertical axis against 1/T on the horizontal axis using the axes below.



(2)

(iii) Use the Arrhenius equation $\ln(\text{rate}) = \frac{-E_A}{R} \times \frac{1}{T} + \text{constant}$, together with your graph to calculate a value of the activation energy, E_A, for this reaction.
Show all steps in your working. Include units in your final answer, which should be given to **two** significant figures.
[Gas constant, $R = 8.31\ J\ K^{-1}\ mol^{-1}$]

(2)

Q2

(Total 13 marks)

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3. Ammonia can be oxidised to form nitrogen(II) oxide and water according to the equation

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g) \quad \Delta H^{\ominus} = -905.6 \text{ kJ mol}^{-1}.$$

In industry, the reaction is carried out at 1123 K with a platinum/rhodium catalyst.

The standard entropy of one mole of each substance in the equation, measured at 298 K, is shown in the table below.

Substance	$S^{\ominus}$ / J mol^{-1}K^{-1}
$NH_3(g)$	+192.3
$O_2(g)$	+205.0
$NO(g)$	+210.7
$H_2O(g)$	+188.7

(a) (i) Use the values given to calculate the standard entropy change of the system, $\Delta S^{\ominus}_{\text{system}}$, for this reaction. Include the sign and units in your final answer.

(2)

(ii) Is the sign for your value for $\Delta S^{\ominus}_{\text{system}}$ what you expected? Justify your answer.

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(1)

(iii) Calculate the entropy change of the surroundings, $\Delta S_{\text{surroundings}}$, at 1123 K for this reaction. Include the sign and units in your final answer.

(2)

Leave blank

(iv) Calculate the total entropy change, ΔS_{total}, for this reaction at 1123 K. Include the sign and units in your final answer. You may assume that ΔS_{system} is unchanged at high temperatures.

(1)

(v) What does your answer to (iv) tell you about the extent of the reaction at 1123 K? Justify your answer.

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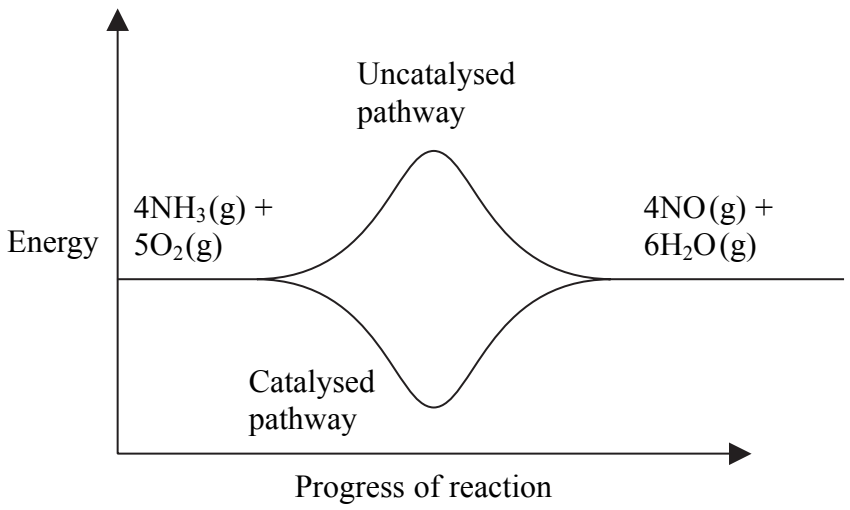
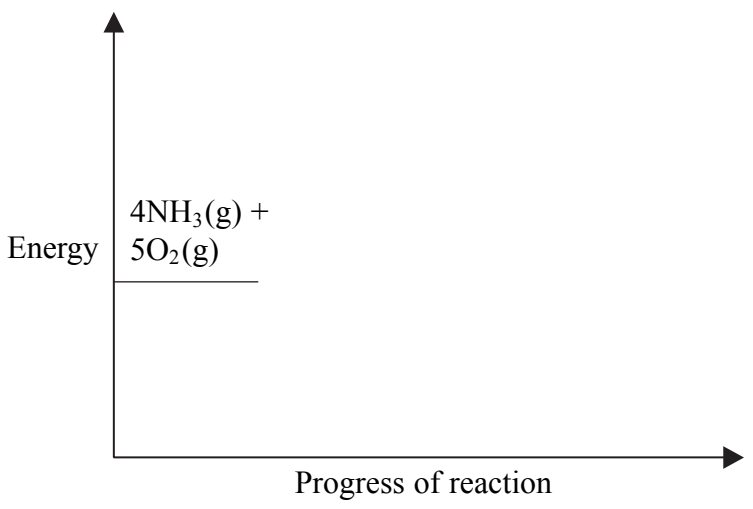
(1)

(vi) An energy profile was proposed to illustrate the effect of the catalyst on this reaction. The proposal has two errors. Draw a corrected version on the axes below.

Proposal



Corrected version



(2)

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(b) The oxidation of nitrogen(II) oxide leads to the following equilibrium

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

The number of moles of each gas in a reaction mixture at equilibrium, at a pressure of 1.5 atm, was found to be

Substance	Number of moles at equilibrium
$NO(g)$	0.025
$O_2(g)$	0.025
$NO_2(g)$	4.95

(i) Write the expression for the equilibrium constant, K_p, for this reaction.

(1)

(ii) Calculate the mole fraction of each gas and hence the value of the equilibrium constant, K_p, for this mixture. Include units, if required, in your answer.

(4)

Leave blank

(iii) What does your answer to (ii) tell you about the position of the equilibrium? Justify your answer.

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(1)

(iv) If the total pressure of the reaction mixture was increased, describe what would happen to the value of the equilibrium constant, K_p, and the partial pressure of $NO_2(g)$. In each case justify your answer.

Equilibrium constant, K_p.

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Partial pressure of $NO_2(g)$.

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(2)

Q3

(Total 17 marks)

Leave blank

4. (a) The table below shows the acid dissociation constants, K_a, of three carboxylic acids.

Acid	Structural formula	K_a / mol dm^{-3}
Chloroethanoic	CH_2ClCO_2H	1.3×10^{-3}
Dichloroethanoic	$CHCl_2CO_2H$	5.0×10^{-2}
Trichloroethanoic	CCl_3CO_2H	2.3×10^{-1}

(i) Write an expression for the acid dissociation constant, K_a, of chloroethanoic acid.

(1)

(ii) Calculate the pH of a 0.0010 mol dm^{-3} solution of chloroethanoic acid, making the usual assumptions.

(3)

(iii) Which acid would have the lowest pH at a concentration of 0.0010 mol dm^{-3}? Use both the data and the structure of the acids to justify your answer. No further calculation is required.

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(2)

Leave blank

(b) Chloroethanoic acid, CH_2ClCO_2H, reacts with methanol, CH_3OH, in the presence of a sulphuric acid catalyst.

(i) Draw the **displayed** formula and give the name of the **organic** product formed.

Displayed Formula

Name .....

(3)

(ii) What name is given to the functional group formed in this organic product?

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(1)

(iii) What type of reagent is methanol in this reaction? Explain why it is able to behave in this way and describe how it attacks the chloroethanoic acid.
You may find it helpful to draw a diagram.

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(3)

(iv) How would you convert the organic product of the reaction between chloroethanoic acid and methanol back into the original compounds?

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(2) **Q4**

(Total 15 marks)

TOTAL FOR PAPER: 60 MARKS

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THE PERIODIC TABLE

Period	1	2	Group										3	4	5	6	7	0
1	1 H Hydrogen 1																	2 He Helium 4
2	3 Li Lithium 7	4 Be Beryllium 9											5 B Boron 11	6 C Carbon 12	7 N Nitrogen 14	8 O Oxygen 16	9 F Fluorine 19	10 Ne Neon 20
3	11 Na Sodium 23	12 Mg Magnesium 24											13 Al Aluminium 27	14 Si Silicon 28	15 P Phosphorus 31	16 S Sulphur 32	17 Cl Chlorine 35.5	18 Ar Argon 40
4	19 K Potassium 39	20 Ca Calcium 40	21 Sc Scandium 45	22 Ti Titanium 48	23 V Vanadium 51	24 Cr Chromium 52	25 Mn Manganese 55	26 Fe Iron 56	27 Co Cobalt 59	28 Ni Nickel 59	29 Cu Copper 63.5	30 Zn Zinc 65.4	31 Ga Gallium 70	32 Ge Germanium 73	33 As Arsenic 75	34 Se Selenium 79	35 Br Bromine 80	36 Kr Krypton 84
5	37 Rb Rubidium 85	38 Sr Strontium 88	39 Y Yttrium 89	40 Zr Zirconium 91	41 Nb Niobium 93	42 Mo Molybdenum 96	43 Tc Technetium (99)	44 Ru Ruthenium 101	45 Rh Rhodium 103	46 Pd Palladium 106	47 Ag Silver 108	48 Cd Cadmium 112	49 In Indium 115	50 Sn Tin 119	51 Sb Antimony 122	52 Te Tellurium 128	53 I Iodine 127	54 Xe Xenon 131
6	55 Cs Caesium 133	56 Ba Barium 137	57 ► La Lanthanum 139	72 Hf Hafnium 178	73 Ta Tantalum 181	74 W Tungsten 184	75 Re Rhenium 186	76 Os Osmium 190	77 Ir Iridium 192	78 Pt Platinum 195	79 Au Gold 197	80 Hg Mercury 201	81 Tl Thallium 204	82 Pb Lead 207	83 Bi Bismuth 209	84 Po Polonium (210)	85 At Astatine (210)	86 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium (226)	89 ►► Ac Actinium (227)	104 Unq Unnil-quadium (261)	105 Unp Unnil-pentium (262)	106 Unh Unnil-hexium (263)												

Key

Atomic Number
Symbol
Name
Molar mass in g mol^{-1}

► Lanthanide elements	58 Ce Cerium 140	59 Pr Praseo-dymium 141	60 Nd Neodymium 144	61 Pm Promethium (147)	62 Sm Samarium 150	63 Eu Europium 152	64 Gd Gadolinium 157	65 Tb Terbium 159	66 Dy Dysprosium 163	67 Ho Holmium 165	68 Er Erbium 167	69 Tm Thulium 169	70 Yb Ytterbium 173	71 Lu Lutetium 175
►► Actinide elements	90 Th Thorium 232	91 Pa Protactinium (231)	92 U Uranium 238	93 Np Neptunium (237)	94 Pu Plutonium (242)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (245)	98 Cf Californium (251)	99 Es Einsteinium (254)	100 Fm Fermium (253)	101 Md Mendelevium (256)	102 No Nobelium (254)	103 Lr Lawrencium (257)