Friday 23 May 2014 – Morning

AS GCE CHEMISTRY B (SALTERS)

F331/01 Chemistry for Life

Candidates answer on the Question Paper.

OCR supplied materials:
- *Data Sheet for Chemistry B (Salters)* (inserted)

Other materials required:
- Scientific calculator

Duration: 1 hour 15 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found inside this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry B (Salters)* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.
- The total number of marks for this paper is **60**.
- This document consists of **12** pages. Any blank pages are indicated.

Answer **all** the questions.

1 Alkenes are important in the chemical industry. Simple alkenes occur naturally and form a small percentage of the hydrocarbons in crude oil.

(a) Name the process used to separate individual groups of hydrocarbons in crude oil.

On which property of the hydrocarbons does this process depend?

name of process ....

property ....

[1]

(b) **(i)** Draw, in the boxes below, the **full** structural formulae for the hydrocarbons propane and propene.

Propane	**Propene**

[1]

(ii) Give the term used to describe molecules, such as alkenes, containing a C=C bond.

.... **[1]**

(c) About 10% of crude oil is converted into alkenes by the process of catalytic cracking.

(i) Write the equation for the cracking of decane to produce ethene and one other product.

Use **molecular** formulae in your equation.

[1]

(ii) Heterogeneous catalysts are used in cracking.

Explain, in the context of catalysis, the term *heterogeneous* and describe the **first** stage in the mechanism of this type of catalysis.

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

....

.... **[2]**

(iii) The shorter chain alkanes produced in the cracking process are useful for blending in petrol, because they have higher octane numbers than the original molecules.

Explain what octane number measures and why a high octane number is desirable for a fuel.

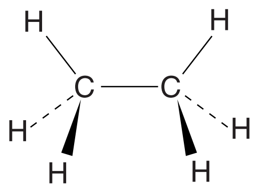
....

....

....

.... **[2]**

(iv) The structure of ethane can be represented by the diagram below.



Explain the significance of the wedges and dotted lines in this structure.

....

.... **[1]**

(v) Reforming is another process used in the oil industry to produce hydrocarbons with high octane numbers. This process produces cyclic hydrocarbons and one other product.

Name this other product.

.... **[1]**

(d) Alkenes are also used in drilling oils. Some of these alkenes are structural isomers.

(i) Explain the meaning of the term *structural isomers.*

....

....

.... **[1]**

(ii) Draw the **skeletal** structures for **three** alkene isomers of C_4H_8.

[2]

(e) 'Isoprene' is produced and emitted into the atmosphere by many species of trees. It can be represented by the following formula.

$$CH_2C(CH_3)CHCH_2$$

Draw the **full** structural formula of isoprene.

[2]

[Total: 15]

2 Coal fired power stations produce the pollutant gas sulfur dioxide, SO_2. This gas is toxic and produces 'acid rain'.

(a) The sulfur dioxide reacts with water and oxygen in the atmosphere to produce sulfuric acid, H_2SO_4.

Write a balanced equation for this reaction.

Include state symbols.

[2]

(b) One way to reduce the sulfur dioxide emissions is to allow the waste gas from the power station to pass through a fine powder of calcium oxide. The following reaction takes place.

$$2CaO(s) + 2SO_2(g) + O_2(g) \rightarrow 2CaSO_4(s)$$

Explain why calcium oxide would be expected to react with sulfur dioxide.

....

.... **[1]**

(c) Both carbon and sulfur form dioxides when burnt.
CO_2 is a linear molecule. SO_2 is a bent (v-shaped) molecule.

Explain why CO_2 is linear and SO_2 is a bent molecule.

Give the bond angle in SO_2.

....

....

....

....

....

Bond angle in SO_2 ....
[4]

(d) The sulfur dioxide is the result of sulfur impurities in the coal burning in air. In some coals, the sulfur content can be up to 10% by mass.

Calculate the mass of sulfur dioxide produced when 1.0 kg of coal is burnt. Assume the sulfur content to be 10% by mass.

mass of SO_2 = ... g **[2]**

(e) A more radical approach to cutting sulfur dioxide pollution is to use alternative energy generation methods, not dependent on fossil fuels.

One such method is to use 'nuclear energy'.

Suggest one advantage (other than production of less SO_2) and one disadvantage of using nuclear energy compared to burning fossil fuels.

advantage ....

....

disadvantage ....

....
[2]

(f) Carbon has a very high melting point and sulfur has a low melting point.

Name the type of bonding **and** structure in carbon and sulfur.

	Type of bonding	**Type of structure**
Carbon		
Sulfur		

[2]

[Total: 13]

3 Terrorists try to smuggle neutron-emitting material across international borders. Neutron detectors are used to combat this.

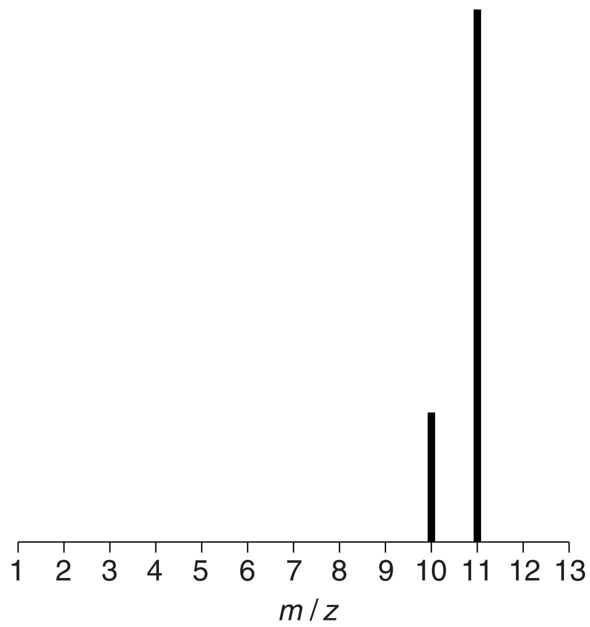
One material that can be used in neutron detectors is the isotope, boron-10.

(a) Boron has two stable isotopes. Complete the table below to show their atomic structures.

Isotope	**Number of protons**	**Number of neutrons**	**Number of electrons**
Boron-10			
Boron-11			

[1]

(b) Analysis of a sample of boron by a time-of-flight mass spectrometer produced the following mass spectrum.



(i) What information is given by the height of the two peaks on the mass spectrum?

....

.... **[1]**

(ii) Explain how the information given on a mass spectrum, such as the one shown above for boron, can be used to calculate the relative atomic mass of an element.

....

....

....

.... **[2]**

(iii) A key stage in the operation of a time-of-flight mass spectrometer is the acceleration of positive ions.

Explain how this process allows the instrument to separate ions of different masses.

....

....

....

....

.... **[3]**

(c) Neutron-emitting material may also produce ionising radiation consisting of alpha or beta particles.

(i) Complete the table below by selecting from the following list.

paper; 4; +2; large; –1; aluminium foil; small; 0

Property	Ionising radiation	
	Alpha (α)	**Beta (β)**
Relative mass		
Relative charge		
Deflection by electrical field		
Stopped by a minimum of …		

[2]

(ii) A boron-10 nucleus absorbs a neutron and splits into an alpha particle and an isotope of a different element. The alpha particles can then be detected.

Complete the following nuclear equation for this process.

$${}^{10}_{5}\mathrm{B} + {}^{1}_{0}\mathrm{n} \longrightarrow \text{...........} + \text{...........}$$

[2]

(iii) It is difficult to detect smuggled radioactive material using the **direct** emission of alpha or beta particles.

Suggest why this is so.

....

.... **[1]**

(d) Another material used in neutron detectors is boron trifluoride, BF_3.

Draw a '*dot-and-cross'* diagram for BF_3, showing outer electrons only.

[2]

(e) The isotope uranium-235 is present in some radioactive material. This breaks down by alpha decay with a half-life of approximately 700 million years.

(i) Explain the term *half-life*.

....

.... **[1]**

(ii) Radioisotopes such as uranium-235 can be used in the dating of geological material. The final product in the decay of uranium-235 is a stable lead isotope.

Explain the principles behind this dating.

....

....

....

.... **[2]**

(iii) Explain why the long half-life of uranium-235 means it cannot be used in dating **archaeological** material.

....

.... **[1]**

(iv) The energy released when uranium-235 breaks down in nuclear reactors can be used to generate electricity. Another process releasing energy is nuclear fusion.

Explain the process of nuclear fusion.

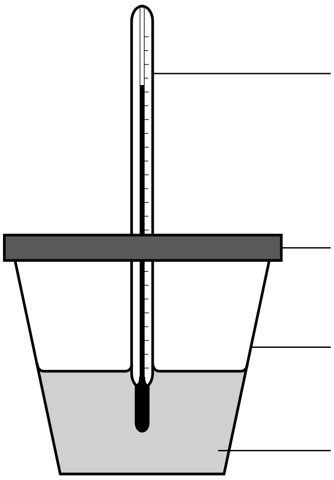
....

.... **[1]**

[Total: 19]

4 Many children's science kits contain the chemicals 'sodium bicarbonate', $NaHCO_3$, and 'citric acid', $C_6H_8O_7$. If solid sodium bicarbonate is added to a solution of citric acid, the resulting evolution of gas can be used to 'power' small toys such as boats and cars.

(a) A student decides to measure the enthalpy change for this reaction using the apparatus below.



The student adds 12 g of sodium bicarbonate to **excess** citric acid solution.
The results are given below.

Mass of solution formed = 25.0 g

Starting temperature of solution = 22 °C

Finishing temperature of solution = 6 °C

(i) Calculate the energy transferred from the solution.

The solution has a specific heat capacity of 4.18 $J\,g^{-1}\,K^{-1}$.

energy transferred = ... J **[1]**

(ii) Calculate the enthalpy change, ΔH, per mole of sodium bicarbonate in this reaction.

Give your answer, in **kJ**, to **two** significant figures.

ΔH = ... $kJ\,mol^{-1}$ **[3]**

(iii) The answer calculated in **(ii)** is different from the value quoted in data books.

Suggest one limitation in the practical procedure which would lead to the difference.

.... **[1]**

(iv) The reaction between sodium bicarbonate and citric acid can be represented by **equation 4.1** below.

$$C_6H_8O_7(aq) + 3NaHCO_3(s) \rightarrow Na_3C_6H_5O_7\,(aq) + 3CO_2(g) + 3H_2O(l) \qquad \textbf{equation 4.1}$$

Calculate the volume of carbon dioxide gas produced, in dm^3, in the student's experiment, at room temperature and pressure. Assume none of the carbon dioxide dissolves.

One mole of gas at room temperature and pressure occupies $24\,dm^3$.

volume of carbon dioxide = ... dm^3 **[2]**

(b) The enthalpy change of a reaction depends on endothermic and exothermic processes.

Describe, in terms of bonds made and broken, which processes are exothermic and which are endothermic. Explain how the relative values of these processes affect the enthalpy change of the reaction in **equation 4.1**.

....

....

....

.... **[2]**

(c) The reaction represented by **equation 4.1** is accompanied by an increase in entropy.

Explain the term *entropy*.

Describe the differences in magnitude of the entropy of a solid, a liquid and a gas and use your answers to explain the increase in entropy accompanying this reaction.

....

....

....

....

....

.... **[4]**

[Total: 13]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page. The question number(s) must be clearly shown in the margin.

Data Sheet for Chemistry B (Salters)

(version 2.2)

GCE Advanced Level and Advanced Subsidiary

Chemistry B (Salters) (H035, H435)

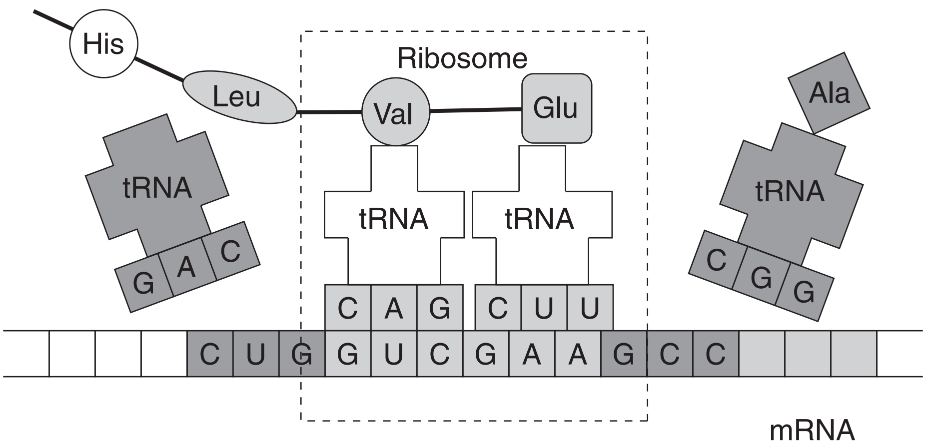
Chemistry units F331–F336

The information in this sheet is for the use of candidates following Chemistry B (Salters) (H035/H435). Copies of this sheet may be used for teaching.

Instructions to Exams Officer/Invigilator

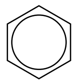
- A copy of this Data Sheet will be included as an insert with each question paper. This should be given up to the Invigilator at the end of the examination.
- **Do not send this Data Sheet for marking; it should be retained in the centre or destroyed.**

Diagram to illustrate protein synthesis



ADAPTED FROM SALTERS' ADVANCED CHEMISTRY: CHEMICAL STORYLINES BY GEORGE BURTON. REPRINTED BY PERMISSION OF HARCOURT EDUCATION

Characteristic infrared absorption in organic molecules

bond	location	wavenumber/cm^{-1}	intensity	
C—H	alkanes alkenes, arenes alkynes	2850–2950 3000–3100 *ca.* 3300	M–S M–S S	M medium S strong * hydrogen bonded
C═C	alkenes	1620–1680	M	
	arenes	several peaks in range 1450–1650	variable	
C≡C	alkynes	2100–2260	M	
C═O	aldehydes ketones carboxylic acids esters amides	1720–1740 1705–1725 1700–1725 1735–1750 1630–1700	S S S S M	
C—O	alcohols, ethers, esters	1050–1300	S	
C≡N	nitriles	2200–2260	M	
C—F	fluoroalkanes chloroalkanes bromoalkanes	1000–1400 600–800 500–600	S S S	
O—H	alcohols, phenols *alcohols, phenols *carboxylic acids	3600–3640 3200–3600 2500–3200	S S (broad) M (broad)	
N—H	primary amines amides	3300–3500 *ca.* 3500	M–S M	

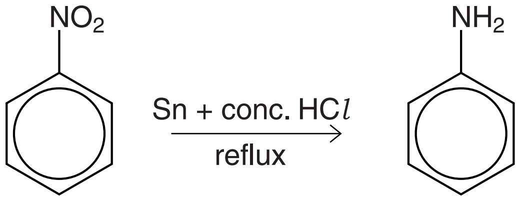
Some useful organic reactions

1 $R{-}Br + CN^- \longrightarrow R{-}CN + Br^-$

2 $R{-}CN \xrightarrow[\text{reflux}]{H^+(aq)/H_2O} R{-}COOH$

3 $RCHO \xrightarrow{NaBH_4} RCH_2OH$

4 $\begin{matrix}R\\ R'\end{matrix}\!\!>C{=}O \xrightarrow{NaBH_4} \begin{matrix}R\\ R'\end{matrix}\!\!>CH{-}OH$

5 

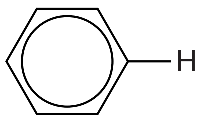
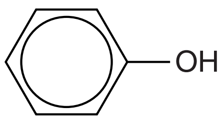
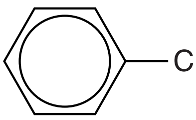
6 $R{-}COOH + SCl_2O \longrightarrow R{-}COCl + SO_2 + HCl$

7 $R{-}OH \xrightarrow{NaBr/\ c.H_2SO_4} R{-}Br$

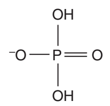
Chemical shifts for some types of protons (^{1}H) in NMR spectra

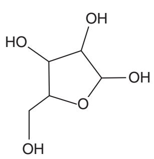
Chemical shifts are for hydrogen (^{1}H) relative to TMS (tetramethylsilane).

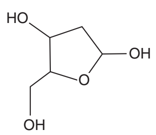
They are typical values and can vary slightly depending on the solvent, concentration and substituents.

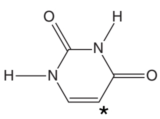
type of proton	chemical shift, δ/ppm	type of proton	chemical shift, δ/ppm
C**H**$_3$—C	0.7–1.6		6.4–8.2
C—C**H**$_2$—C C—C**H**—C │ C	1.4–2.3	—C—C**H**O	9.4–10.0
>C**H**—C(=O)— carbonyls, esters, amides, acids	2.0–2.7	—C—O**H**	0.5–4.5*
—C**H**—N amines, amides	2.3–2.9		4.5–10.0*
	2.3–3.0	—C—N**H**	1.0–5.0*
—O—C**H** alcohols, esters, ethers	3.3–4.8	—CO—N**H**	5.0–12.0*
—C**H**—C*l* or Br	3.0–4.2	—CO—O**H**	9.0–15.0*
—C**H**═C**H**—	4.5–6.0	*these signals are *very* variable (sometimes outside these limits) and often broad.	

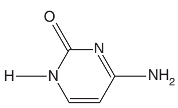
Monomers of DNA and RNA

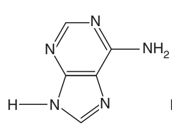

phosphate

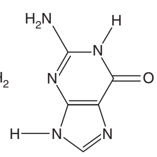

ribose


deoxyribose


uracil


cytosine


adenine


guanine

(thymine has a CH_3 at position *)

The Periodic Table of the Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1	2											3	4	5	6	7	0
							1.0 **H** hydrogen 1										4.0 **He** helium 2
6.9 **Li** lithium 3	9.0 **Be** beryllium 4											10.8 **B** boron 5	12.0 **C** carbon 6	14.0 **N** nitrogen 7	16.0 **O** oxygen 8	19.0 **F** fluorine 9	20.2 **Ne** neon 10
23.0 **Na** sodium 11	24.3 **Mg** magnesium 12											27.0 **Al** aluminium 13	28.1 **Si** silicon 14	31.0 **P** phosphorus 15	32.1 **S** sulfur 16	35.5 **Cl** chlorine 17	39.9 **Ar** argon 18
39.1 **K** potassium 19	40.1 **Ca** calcium 20	45.0 **Sc** scandium 21	47.9 **Ti** titanium 22	50.9 **V** vanadium 23	52.0 **Cr** chromium 24	54.9 **Mn** manganese 25	55.8 **Fe** iron 26	58.9 **Co** cobalt 27	58.7 **Ni** nickel 28	63.5 **Cu** copper 29	65.4 **Zn** zinc 30	69.7 **Ga** gallium 31	72.6 **Ge** germanium 32	74.9 **As** arsenic 33	79.0 **Se** selenium 34	79.9 **Br** bromine 35	83.8 **Kr** krypton 36
85.5 **Rb** rubidium 37	87.6 **Sr** strontium 38	88.9 **Y** yttrium 39	91.2 **Zr** zirconium 40	92.9 **Nb** niobium 41	95.9 **Mo** molybdenum 42	[98] **Tc** technetium 43	101.1 **Ru** ruthenium 44	102.9 **Rh** rhodium 45	106.4 **Pd** palladium 46	107.9 **Ag** silver 47	112.4 **Cd** cadmium 48	114.8 **In** indium 49	118.7 **Sn** tin 50	121.8 **Sb** antimony 51	127.6 **Te** tellurium 52	126.9 **I** iodine 53	131.3 **Xe** xenon 54
132.9 **Cs** caesium 55	137.3 **Ba** barium 56	138.9 **La*** lanthanum 57	178.5 **Hf** hafnium 72	180.9 **Ta** tantalum 73	183.8 **W** tungsten 74	186.2 **Re** rhenium 75	190.2 **Os** osmium 76	192.2 **Ir** iridium 77	195.1 **Pt** platinum 78	197.0 **Au** gold 79	200.6 **Hg** mercury 80	204.4 **Tl** thallium 81	207.2 **Pb** lead 82	209.0 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	Elements with atomic numbers 112–116 have been reported but not fully authenticated						

140.1 **Ce** cerium 58	140.9 **Pr** praseodymium 59	144.2 **Nd** neodymium 60	144.9 **Pm** promethium 61	150.4 **Sm** samarium 62	152.0 **Eu** europium 63	157.2 **Gd** gadolinium 64	158.9 **Tb** terbium 65	162.5 **Dy** dysprosium 66	164.9 **Ho** holmium 67	167.3 **Er** erbium 68	168.9 **Tm** thulium 69	173.0 **Yb** ytterbium 70	175.0 **Lu** lutetium 71
232.0 **Th** thorium 90	[231] **Pa** protactinium 91	238.1 **U** uranium 92	[237] **Np** neptunium 93	[242] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[245] **Bk** berkelium 97	[251] **Cf** californium 98	[254] **Es** einsteinium 99	[253] **Fm** fermium 100	[256] **Md** mendelevium 101	[254] **No** nobelium 102	[257] **Lr** lawrencium 103

GCE Chemistry B (Salters)