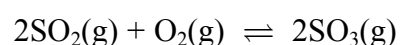


Answer ALL the questions. Write your answers in the spaces provided.

1. One stage in the manufacture of sulphuric acid is the exothermic reaction



(a) In a closed container this mixture of gases would be in dynamic equilibrium. State the meaning of the words **dynamic** and **equilibrium** in this context.

.....
.....
.....
.....

(2)

(b) (i) State the conditions of temperature and pressure used industrially for the manufacture of SO₃.

.....
.....

(2)

(ii) Justify the choice of **temperature** for this reaction in terms of yield and rate.

.....
.....
.....
.....
.....
.....

(3)

(iii) The yield of products would be greater if a higher pressure were to be used for the reaction.

Suggest a reason why a higher pressure than you have given in (i) is **not** used.

.....
.....
.....

(1)



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blank

(c) (i) Calculate ΔH for the forward reaction, given the enthalpies of formation below.

	$\Delta H_f / \text{kJ mol}^{-1}$
$\text{SO}_2(\text{g})$	- 297
$\text{SO}_3(\text{g})$	- 395
$\text{O}_2(\text{g})$	0

(2)

(ii) State why the enthalpy of formation of oxygen, $\text{O}_2(\text{g})$, is zero.

.....

.....

(1)



Leave blank

(d) (i) State the **formula** of the catalyst used in the industrial process.

.....

(1)

(ii) Draw an enthalpy level diagram to show the reaction profiles of the uncatalysed and catalysed reactions.

(3)

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

.....
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.....

(2)



(e) Suggest why the sulphur trioxide produced is passed into concentrated sulphuric acid rather than water to form sulphuric acid at the end of the process.

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(1)

(Total 18 marks)

Leave blank

Q1

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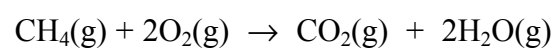


2. (a) State Hess's Law.

.....

(2)

(b) Methane burns in oxygen.



(i) Calculate the enthalpy change for this reaction, using the bond enthalpies given below.

	Bond enthalpy / kJ mol ⁻¹
C-H	+435
O=O	+498
C=O	+805
H-O	+464

(3)

(ii) State the name of this enthalpy change.

.....

(1)

(iii) The value of this enthalpy change, under standard conditions, is - 890 kJ mol⁻¹. State the meaning of **standard conditions**.

.....

(2)



Leave
blank

(iv) Suggest, with a reason, why the enthalpy change calculated in (i) is different from the standard value quoted in (iii).

.....
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.....
.....

(2)

(c) Although the reaction between methane and oxygen is exothermic, it does not occur unless the mixture is ignited.

Use these facts to explain the difference between thermodynamic and kinetic stability.

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(4)

(Total 14 marks)

Q2

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Leave blank

3. Bromine reacts with both ethane, C_2H_6 , and ethene, C_2H_4 .

(a) The reaction of bromine with ethane occurs in ultraviolet light.

(i) By what type of mechanism does this substitution reaction occur?

.....
(1)

(ii) Write the equation for a reaction of ethane with bromine.

(1)

(b) Bromine reacts rapidly with ethene without the need for light.

(i) Give the equation for this reaction using structural formulae.

(2)

(ii) Name the product.

(1)

(c) Explain, in terms of the bonding in the two hydrocarbons, why the reaction of bromine with ethene occurs so much more readily than that with ethane.

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(3)

(Total 8 marks)

Q3



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4. (a) (i) Draw the structural formulae of the two geometric isomers of but-2-ene, C_4H_8 .

(2)

(ii) Explain, in terms of structure and bonding, why but-2-ene exists as two geometric isomers whereas but-1-ene does not.

.....
.....
.....
.....

(3)

(iii) Draw the structural formula of another isomer with formula C_4H_8 .

(1)

(b) Alkenes can be used to make polymers.

(i) Draw enough of the chain of poly(propene) to make its structure clear.

(2)

(ii) Explain why poly(alkenes) cause problems when they are disposed of in a landfill site.

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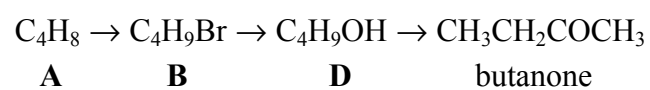
(2)

(Total 10 marks)

Q4



5. Consider the following series of reactions



Compound **A** has an unbranched chain.

(a) (i) Draw the structure of the alcohol **D** which is oxidised to butanone.

(1)

(ii) State the reagents and conditions used to oxidise **D** to butanone.

.....
.....

(3)

(iii) Suggest reagents and conditions for conversion of the halogenoalkane **B** to alcohol **D**.

.....
.....

(2)

(iv) When compound **A** reacts with HBr, only one product, **B**, is formed.
Draw the structural formula of compound **A**.

(1)

(b) An isomer of **D** is **not** oxidised under the conditions used in (a)(ii).

Draw the structural formula of this **isomer** of **D**.

(1)



Leave
blank

(c) If the conditions used in (a)(iii) to convert **B** to **D** are changed, then **B** will give two organic products: the original compound **A** and a structural isomer **G**.

Both **A** and **G** have an unbranched chain and molecular formula C_4H_8 . **G** reacts with HBr to form two isomers with formula C_4H_9Br .

(i) Draw the structural formula of **G**.

(1)

(ii) In what way are the conditions changed to give this result?

.....
.....

(1)

Q5

(Total 10 marks)

TOTAL FOR PAPER: 60 MARKS

END



THE PERIODIC TABLE

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

1	4
H Hydrogen	He Helium
1	2

Key	
Molar mass g mol ⁻¹	Symbol
Name	Atomic number

7	9
Li Lithium	Be Beryllium
3	4
23	24
Na Sodium	Mg Magnesium
11	12

39	40	45	48	51	52	55	56	59	59	63.5	65.4	70	73	75	79	80	84	84
K Potassium	Ca Calcium	Sc Scandium	Ti Titanium	V Vanadium	Cr Chromium	Mn Manganese	Fe Iron	Co Cobalt	Ni Nickel	Cu Copper	Zn Zinc	Ga Gallium	Ge Germanium	As Arsenic	Se Selenium	Br Bromine	Kr Krypton	Ne Neon
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	10
85	88	89	91	93	96	99	101	103	106	108	112	115	119	122	128	127	131	40
Rb Rubidium	Sr Strontium	Y Yttrium	Zr Zirconium	Nb Niobium	Mo Molybdenum	Tc Technetium	Ru Ruthenium	Rh Rhodium	Pd Palladium	Ag Silver	Cd Cadmium	In Indium	Sn Tin	Sb Antimony	Te Tellurium	I Iodine	Xe Xenon	Ar Argon
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	17
133	137	139	178	181	184	186	190	192	195	197	201	204	207	209	210	210	222	18
Cs Caesium	Ba Barium	La Lanthanum	Hf Hafnium	Ta Tantalum	W Tungsten	Re Rhenium	Os Osmium	Ir Iridium	Pt Platinum	Au Gold	Hg Mercury	Pb Lead	Bi Bismuth	Po Polonium	At Astatine	Rn Radon	Ne Neon	15
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	16
223	226	227	227	227	227	227	227	227	227	227	227	227	227	227	227	227	227	14
Fr Francium	Ra Radium	Ac Actinium																13
87	88	89																11

140	141	144	150	152	157	159	163	165	167	169	173	175
Ce Cerium	Pr Praseodymium	Nd Neodymium	Sm Samarium	Eu Europium	Gd Gadolinium	Tb Terbium	Dy Dysprosium	Ho Holmium	Er Erbium	Tm Thulium	Yb Ytterbium	Lu Lutetium
58	59	60	62	63	64	65	66	67	68	69	70	71

232	(231)	238	(237)	(242)	(243)	(245)	(251)	(254)	(253)	(256)	(254)	(257)
Th Thorium	Pa Protactinium	U Uranium	Np Neptunium	Pu Plutonium	Am Americium	Bk Berkelium	Cf Californium	Es Einsteinium	Fm Fermium	Md Mendelevium	No Nobelium	Lr Lawrencium
90	91	92	93	94	95	97	98	99	100	101	102	103

