14.4 Alkanes

01. 0620_s21_qp_42 Q: 2

Silver has an atomic number of 47.

(a) Naturally occurring atoms of silver are ^{107}Ag and ^{109}Ag.

(i) State the name given to atoms of the same element with different nucleon numbers.

..... [1]

(ii) Complete the table to show the number of protons, neutrons and electrons in each atom and ion of silver shown.

	$^{107}_{47}Ag$	$^{109}_{47}Ag^{+}$
protons		
neutrons		
electrons		

[3]

(iii) Complete this definition of relative atomic mass.

Relative atomic mass is the ..... mass of naturally occurring atoms of an element on a scale where the ..... atom has a mass of exactly ..... units.

[3]

(iv) A sample of silver has a relative atomic mass of 108.0.

Deduce the percentage of ^{107}Ag present in this sample of silver.

..... [1]

(b) Silver nitrate is a salt of silver made by reacting silver oxide with an acid.

Write the formula of the acid which reacts with silver oxide to form silver nitrate.

..... [1]

(c) Aqueous silver nitrate is a colourless solution containing $Ag^+(aq)$ ions.

(i) Describe what is seen when aqueous silver nitrate is added to aqueous sodium iodide, NaI(aq).

..... [1]

(ii) Write the ionic equation for the reaction between aqueous silver nitrate and aqueous sodium iodide.
Include state symbols.

..... [3]

(d) In the positive test for aqueous nitrate ions, aqueous sodium hydroxide and one other substance are warmed with the nitrate ions.

Name this other substance and the gas formed.

name of substance .....

name of gas .....
[2]

(e) When silver nitrate is exposed to sunlight, silver is formed.

Name the type of reaction which needs light to make it happen.

..... [1]

(f) Members of one homologous series only react with chlorine in the presence of sunlight.

(i) Name a member of this homologous series.

..... [1]

(ii) Name **two** products that form when the compound in **(i)** reacts with chlorine.

1 .....

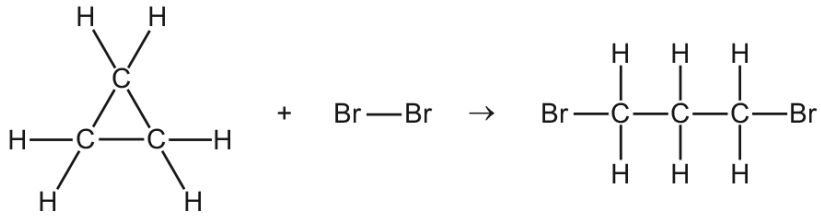
2 .....
[2]

[Total: 19]

02. 0620_s17_qp_43 Q: 2

Cyclopropane is a colourless gas.

Cyclopropane reacts with bromine at room temperature. The chemical equation for the reaction is shown.



cyclopropane + bromine → dibromopropane

(a) (i) What is the empirical formula of cyclopropane?

..... [1]

(ii) What colour change, if any, would you see when cyclopropane is bubbled into aqueous bromine?

initial colour .....

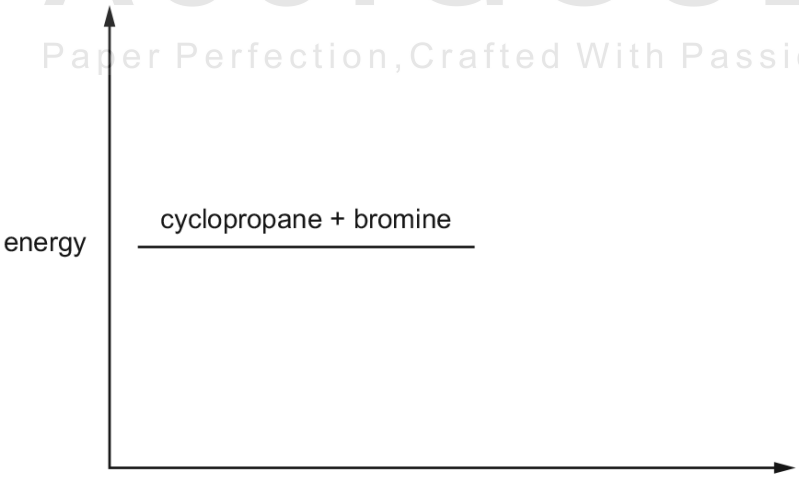
final colour .....

[2]

(b) The reaction of cyclopropane with bromine is exothermic.

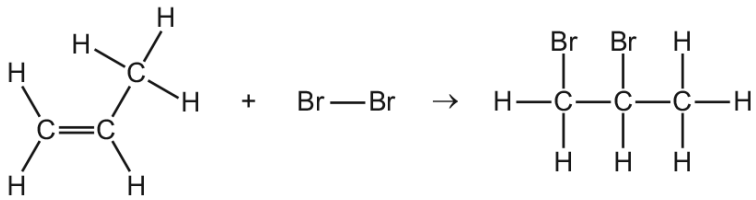
(i) Complete the energy level diagram for this reaction by

- adding the product of the reaction,
- labelling the energy change, ΔH.



[2]

(ii) Propene also reacts with bromine.



Use the bond energies in the table to calculate the energy change, ΔH, for the reaction.

	C–H	C–C	Br–Br	C–Br	C=C
bond energy in kJ/mol	412	348	193	285	611

energy change = ... kJ/mol [3]

(c) The boiling point of bromine is 59 °C and the boiling point of iodine is 184 °C.

Explain why iodine has a higher boiling point than bromine.

.....

.....

.....

.....

..... [2]

[Total: 10]

03. 0620_s13_qp_33 Q: 4

Germanium is an element in Group IV. The electron distribution of a germanium atom is 2 + 8 + 18 + 4. It has oxidation states of +2 and +4.

(a) Germanium forms a series of saturated hydrides similar to the alkanes.

(i) Draw the structural formula of the hydride which contains three germanium atoms per molecule.

[1]

(ii) Predict the general formula of the germanium hydrides.

..... [1]

(b) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound germanium(IV) chloride, $GeCl_4$.

Use o to represent an electron from a chlorine atom.
Use x to represent an electron from a germanium atom.

[2]

(c) Describe the structure of the giant covalent compound germanium(IV) oxide, GeO_2.
It has a similar structure to that of silicon(IV) oxide.

.....

.....

..... [3]

(d) Is the change $GeCl_2$ to $GeCl_4$ reduction, oxidation or neither? Give a reason for your choice.

.....

..... [2]

[Total: 9]

04. 0620_w13_qp_31 Q: 7

(a) The following are two examples of substitution reactions. Only the reaction involving chlorine is a photochemical reaction.

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$$

$$CH_4 + Br_2 \rightarrow CH_3Br + HBr$$

(i) Explain the phrase *substitution reaction*.

.....

..... [1]

(ii) How do photochemical reactions differ from other reactions?

.....

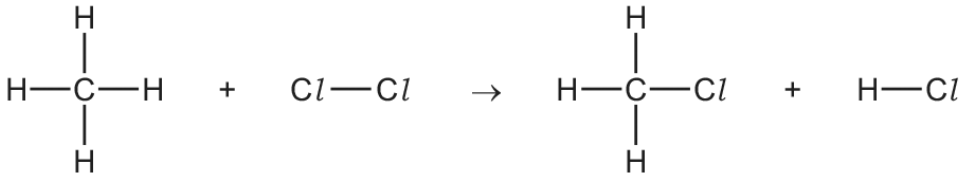
..... [1]

(b) Bond forming is exothermic, bond breaking is endothermic. Explain the difference between an exothermic reaction and an endothermic reaction.

.....

..... [2]

(c) Use the bond energies to show that the following reaction is exothermic.
Bond energy is the amount of energy (kJ / mol) which must be supplied to break one mole of the bond.



Bond energies in kJ / mol

C*l*–C*l*	+242
C–C*l*	+338
C–H	+412
H–C*l*	+431

bonds broken	energy in kJ / mol
.....	.....
.....	.....
total energy =	.....

bonds formed	energy in kJ / mol
.....	.....
.....	.....
total energy =	.....

.....

..... [4]

[Total: 8]

05. 0620_w12_qp_31 Q: 5

Carbonyl chloride, $COCl_2$, is widely used in industry to make polymers, dyes and pharmaceuticals.

(a) Carbonyl chloride was first made in 1812 by exposing a mixture of carbon monoxide and chlorine to bright sunlight. This is a photochemical reaction.

$$CO(g) + Cl_2(g) \rightarrow COCl_2(g)$$

(i) Explain the phrase *photochemical reaction*.

.....

..... [2]

(ii) Give another example of a photochemical reaction and explain why it is important either to the environment or in industry.

.....

.....

..... [3]

(b) Carbonyl chloride is now made by the reversible reaction given below.

$$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$$

The forward reaction is exothermic.
The reaction is catalysed by carbon within a temperature range of 50 to 150 °C.

(i) Predict the effect on the yield of carbonyl chloride of increasing the pressure. Explain your answer.

.....

..... [2]

(ii) If the temperature is allowed to increase to above 200 °C, very little carbonyl chloride is formed. Explain why.

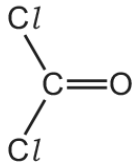
.....

..... [2]

(iii) Explain why a catalyst is used.

..... [1]

(c) The structural formula of carbonyl chloride is given below.



Draw a diagram showing the arrangement of the outer (valency) electrons in one molecule of this covalent compound.

Use o to represent an electron from a carbon atom.
Use x to represent an electron from a chlorine atom.
Use ● to represent an electron from an oxygen atom.

[3]

[Total: 13]

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Question	Answer	Marks
(a)(i)	isotopes	1
(a)(ii)	mark by row ^{107}Ag / $^{109}Ag^+$ p: 47 / 47 n: 60 / 62 e: 47 / 46	3

Question	Answer	Marks
(a)(iii)	average / mean ^{12}C 12	3
(a)(iv)	50(%)	1
(b)	HNO_3	1
(c)(i)	yellow precipitate	1
(c)(ii)	$Ag^+(aq) + vI^-(aq) \rightarrow AgI(s)$ AgI (as only product) (1) Ag^+ and I^- (as *only* reactants) (1) state symbols (1)	3
(d)	aluminium (1) ammonia (1)	2
(e)	photochemical	1
(f)(i)	any **named** alkane	1
(f)(ii)	name of organic product derived from **2(f)(i)** (1) hydrogen chloride / HC*l* (1)	2

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(a)(i)	CH_2	1
(a)(ii)	initial colour: orange	1
	final colour: colourless / none	1
(b)(i)	approximately horizontal line draw to right of and below the reagent line	1
	energy change shown starting level with the reactant energy **AND** finishing level with the product energy **AND** having only one (correct) arrow head **AND** labelled ΔH / energy change	1
(b)(ii)	(energy required to break bonds =) 3624	1
	(energy given out when bonds made =) 3738	1
	–114 (kJ / mol)	1
(c)	(attractive) forces between molecules	1
	(forces of attraction) are stronger in iodine	1

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(a) (i) any ambiguous formula, e.g. GeH_3-GeH_2-GeH_3 [1]

(ii) Ge_nH_{2n+2} [1]
NOT C instead of Ge

(b) correct formula
COND 4bps around germanium atom [1]
COND 3nbps and 1bp around each chlorine atom [1]

(c) four oxygen atoms around each germanium atom [1]
two germanium atoms around each oxygen atom [1]
tetrahedral [1]

(d) oxidation [1]
COND increase in oxidation number [1]
ACCEPT: electron loss

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(a) (i) hydrogen (atoms) replaced by (atoms) of a different element e.g. chlorine [1]
NOT: substitute

(ii) light required [1]

(b) exothermic reaction gives out energy [1]
endothermic reaction absorbs
takes in energy [1]

(c)

bonds broken	energy	
C-H	+412	
C*l*-C*l*	+242	
total energy	+654	[1]

bonds formed	energy	
C-C*l*	–338	
H-C*l*	–431	
total energy	–769	[1]
energy change	–115	[1]

negative sign indicates exothermic [1]

[Total: 8]

(a) (i) rate of reaction; [1]
influenced by light / only happens in light; [1]
or:
turns light into chemical energy = [2]
accept: light is catalyst = [1]

(ii) reduction of silver halides; [1]
they are reduced to silver / $2AgCl \rightarrow 2Ag + Cl_2$; [1]
appropriate importance given; [1]
or:
photosynthesis;
correct comment about chemistry carbon dioxide to carbohydrates / carbon dioxide to oxygen;
anything sensible e.g. its role in the food chain or decrease greenhouse effect or oxygen for respiration;
or:
chlorination;
making chloroalkanes;
appropriate importance given;

(b) (i) pressure would move position of equilibrium to right / increase yield of $COCl_2$; [1]
increase pressure favours side with less (gas) molecules / smaller volume; [1]

(ii) increase temperature favours endothermic reaction; [1]
so less products / reduce yield; [1]

(iii) keeps rate high / increase rate at lower temperatures; [1]

(c) each chlorine 1 bp and 3 nbps; [1]
4 e between carbon atom and oxygen atom; [1]
2 nbps on oxygen atom; [1]

[Total: 13]