Question number	Answer	Notes	Marks
1 a	(A) refinery gases (F) bitumen		2
b	M1 (compound/molecule/substance containing) carbon and hydrogen/C and H (atoms/elements) M2 only	Reject atom/element/ion/mixture in place of compound/molecule/substance Reject compound/molecule/substance in place of atom/element Ignore references to bonds / long chains Accept other terms with same meaning, eg solely / exclusively / just M2 DEP on mention of carbon and hydrogen/C and H and no other element	2

Question number	Answer	Notes	Marks
1 c	(fuel oil molecules/it/they) M1 have higher boiling points M2 are darker (in colour) M3 have higher viscosities / are more viscous	Accept converse statements about gasoline Ignore reference to melting points Ignore stronger / more intense (colours) If specific colours stated, award M2 if valid comparison, eg gasoline is yellow and fuel oil is brown, fuel oil is browner Accept thicker/stickier/flows less easily, etc in place of more viscous If gasoline, accept thinner/runnier/flows more easily, etc in place of less viscous Must be a comparison, eg not enough to say fuel oil has a high boiling point unless also a statement that gasoline has a low boiling point MAX 2 if no comparison Accept reference to fractions near the top/up the column in place of gasoline Accept reference to fractions near the bottom/down the column in place of fuel oil	3

d	i	silica / silicon dioxide / SiO_2 OR alumina / aluminium oxide / Al_2O_3	Accept aluminosilicate(s) / zeolites Ignore silica oxide and alumina oxide	1
	ii	M1 C_2H_4 M2 C_3H_6	Accept in either order Award 1 mark for C_4H_8 and CH_2	2

Question number	Answer	Notes	Marks
1 e i	insufficient/lack of air / oxygen OWTTE	Accept oxygen not in excess Reject no oxygen	1
ii	carbon monoxide / CO		1
iii	decreases capacity of blood (cells) to carry oxygen OR stops blood (cells) from carrying oxygen	Accept CO combines with haemoglobin / forms carboxyhaemoglobin Accept CO displaces/replaces oxygen in haemoglobin Ignore CO combines with red blood cells Ignore references to suffocation / lack of oxygen in lungs stopping breathing / gas exchange Ignore just affects haemoglobin Reject destroys haemoglobin Mark all parts independently	1

Question number	Answer	Notes	Marks
1 f i	M1 sulfur dioxide AND sulfur trioxide in correct order	Accept names with correct oxidation states	2
	M2 sulfuric acid	Ignore dilute / concentrated Ignore hydrogen sulfate / hydrogensulfate	
ii	M1 acid rain	Accept makes lakes acidic / lowers pH of lakes	2
	M2 specific adverse effect on specific object	**plants** plants/trees/vegetation/crops/named example eg dies/stunted growth/harmed/damaged/poisoned Ignore deforestation Ignore leaching minerals **fish** fish/aquatic animals/pond life/marine life/named example eg dies/stunted growth/harmed/damaged/poisoned Ignore references to just animals Accept **limestone** limestone/marble reacts/corrodes/is eaten away NOT just buildings Ignore rusts or physical process such as erosion / weathering / wearing away / dissolving Accept destroys for adverse effect in all of above	
			Total 17 marks

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>2 (a)</td><td><u>fractional</u> distillation</td><td>accept fractionation</td><td>1</td></tr>
<tr><td>(b)</td><td><table><tr><th>Fraction</th><th>Description</th></tr><tr><td>A</td><td>it contains only gases</td></tr><tr><td>F</td><td>it is the most viscous</td></tr><tr><td>F</td><td>it contains bitumen</td></tr></table></td><td></td><td>1
1
1</td></tr>
<tr><td>(c)</td><td>as the number of carbon atoms/it/they increases the boiling point increases</td><td>accept reverse argument

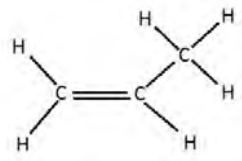
allow positive correlation

ignore (directly) proportional
ignore references to hydrogen atoms</td><td>1</td></tr>
<tr><td colspan="4">Total 5 marks</td></tr>
</table>

Question number	Answer	Accept	Reject	Marks
3 (a) (i)	**D** - hydrocarbons			1
(b)	S U R V T First mark for S in box 1 AND R in box 3 Second mark for V in box 4 AND T in box 5			2

(Total marks for Question 3 = 3 marks)

Question number			Answer	Notes	Marks
4	a	i	heated	Accept boiled / evaporated / vaporised Reject burn Ignore melts	1
		ii	(compounds containing) hydrogen and carbon	Accept substances/molecules containing … Reject atoms/elements //mixture containing … Reject hydrogen and carbon molecules/ions	1
			only	Accept alternatives such as solely M2 needs a reference to hydrogen and carbon	1
		iii	(hydrocarbons/molecules in) D have: higher boiling point larger/bigger/heavier/longer molecules more viscous/thicker/less runny	Ignore melting point If no reference to D or F, then 0/3 Accept converse statements for F	1 1 1
4	b	i	silica / alumina (catalyst)	Accept aluminosilicate / Al_2O_3 / SiO_2 / zeolite /broken ceramic/porous pot	1
			600 – 700 °C	Accept any value or range within this range Units required Accept equivalent values in K	1
		ii	(alkene has) double bond (between C atoms) OR alkane has only single bonds / no double bonds / no multiple bonds	Assume it = alkenes Accept multiple bonds Reject triple bonds Reject references to ionic bonding Ignore references to intermolecular forces	1

Question number			Answer	Notes	Marks
4		iii	C_2H_4	Accept structural and displayed formula Penalise incorrectly shown formulae eg eg C2H4 / C_2h_4 / C_2 + H_4	1
	c	i	propene	Accept propylene / prop-1-ene Reject incorrect spellings	1
		ii	general empirical		1 1
				Accept methyl group in any position Ignore shape and bond angles	1
		iii	CH_3 H CH_3 H | | | | —C——C——C——C— | | | | H H H H	M1 for <u>two</u> carbon atoms both with 2 H atoms M2 for <u>two</u> carbon atoms both with 1 H atom and 1 CH_3 group No M2 if methyl groups on 1st + 2nd, or 3rd + 4th carbons in chain Do not penalise bonds to H of CH_3 Max 1 if chain extended correctly 0/2 if any double bonds shown Ignore brackets and $_n$	2

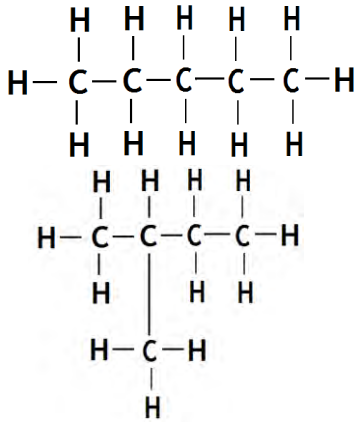
(Total for Question 4 = 16 marks)

Question number	Expected Answer	Accept	Reject	Marks
5 (a) (i)	M1 contains carbon and hydrogen (atoms / elements / particles)	C and H for carbon and hydrogen	ions / carbon molecules / hydrogen molecules / H_2 / mixture of C and H	1
	M2 only	other equivalent words, eg solely / entirely / completely		1
	M2 DEP on M1, but allow M2 if molecules / ions / mixture used in M1			
(ii)	$C_{10}H_{22}$ IGNORE structural formula	$H_{22}C_{10}$	Reject superscripts / lower case c or h / full size numbers	1
(b) (i)	addition	additional		1
(ii)	M1 one of the bonds in the double bond breaks	double bond breaks / double bond becomes single bond / changes (from unsaturated) to saturated		1
	M2 (many) ethene(s)/molecules/monomers join (together) OR (many) ethene(s)/molecules/monomers form a chain			1

Question number	Expected Answer	Accept	Reject	Marks
5 (c)	Any 4 from: • produces smaller / shorter (chain) molecules • smaller / shorter (chain) molecules more useful (as fuels) / have greater demand • smaller / shorter (chain) molecules burn more cleanly /are used to make petrol/diesel/fuel for vehicles • crude oil richer in / has a surplus of long (chain) molecules • produces alkenes / any named alkene • alkenes used to make alcohol / polymers / plastics / chemical feedstock / any named addition polymer	ORA low(er) demand products converted to high(er) demand products ORA		4

Question number	Answer	Notes	Marks
6 a	fractional distillation/fractionating column/tower (crude oil) heated/vaporised / boiled cooler at top/hotter at bottom/idea of temperature gradient fractions condense /separate at different heights/levels fractions have different boiling points/ranges	Reference to fractional / fractionating needed Ignore references to fracking Accept components / hydrocarbons / compounds / gases Accept separate at different temperatures Ignore references to melting point Any four for 1 mark each If any reference to cracking, MAX 2 M1 - M4 can be scored from suitably labelled diagram	4

Question number	Answer	Notes	Marks
6 b i	C_nH_{2n+2}	Do not penalise inappropriate spaces or failure to show 2 and n as subscripts	1
ii	same/similar chemical properties/reactions/behaviour/characteristics gradation / gradual change / trend / increase / decrease of physical properties same functional group (neighbouring) members differ by CH_2	Ignore specific examples such as react with oxygen Ignore similar (type of) reactivity Do not penalise reference to trends Accept reference to specific property, eg boiling point Reject same / similar physical properties Ignore variable physical properties Ignore reference to specific group Any two for 1 each Accept two answers on one answer line Ignore any reference to properties not specified as physical or chemical	2
c	(1) 5 3 4	Accept multiples and fractions	1
d i	carbon monoxide / CO		1
ii	reduces capacity of blood to carry oxygen / OWTTE	Accept correct explanation involving haemoglobin Ignore references to carbon monoxide reacting with blood / red blood cells	1
iii	nitrogen/N_2 AND oxygen/O_2	Accept in either order Ignore N and O	1

Question number	Answer	Notes	Marks
6 e		Penalise missing H atoms once only provided all bonds are correctly shown Penalise missing bonds in both structures	1 1

Question number	Answer	Notes	Marks
6 f i	setting out correct division of each % by A_r OR 4.4, 11.1 and 1.1	Award 0/3 if division by any atomic numbers / wrong way up / multiplication used / wrong atomic mass (eg 16 for C) Do not penalise roundings and minor misreads of % values, eg 11 for H and 36.5 for S If molecular mass used for H, no M1, but can award M2 and M3 but no CQ in ii Using 2 for H gives C_4H_5S Working required for this answer	1
	division by smallest /ratio of 4 : 10 : 1	M2 subsumes M1	1
	$C_4H_{10}S_{(1)}$	Accept elements in any order Award 3 for correct final answer with no working No ECF from M2 Accept use of 90 from ii, i.e. 90 × 0.533 = 48 etc scores M1 ratio scores M2, answer scores M3	1
ii	$C_4H_{10}S_{(1)}$	Accept elements in any order No other answer acceptable	1
			Total 17 marks