F332 Chemistry of Natural Resources

Question			Expected Answers	Marks	Additional Guidance
1	(a)		chlorine is volatile / a gas (1) ; toxic / poisonous / causes respiratory diseases / choking gas (1) ;	2	**do not allow** harmful / irritant / dangerous instead of toxic.
	(b)	(i)	(moles NaCl =) 100000 / 58.5 (= 1709) (1) ; moles Cl_2 = ½ moles NaCl (1) ; volume Cl_2 = moles Cl_2 x 24 (= 20513dm^3) (1) ;	3	indication of halving mols of NaC*l* or doubling 58.5 = 117 **allow** any number of significant figures including 1sf. **allow** a volume of 20508dm^3, which is obtained if the rounded up value for the moles of NaC*l* is used.
		(ii)	100% atom economy (1) ;	1	**ignore** high atom economy **allow** all products are useful **allow** no waste products **ignore** references to side reactions
	(c)	(i)	*Diaphragm cell: advantage* no environmental concerns / uses less electricity / uses less energy (1) ; *disadvantage* uses lots of steam / chlorine / Cl_2 / product must be purified(1) ;	2	
		(ii)	the required transportation links are already there / skilled workforce lives locally / near to necessary raw materials / links to electricity / shared facilities / shared resources / easier to obtain planning permission / existing infrastructure / risks concentrated in one area(1) ;	1	

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		(iii)	$2Cl^- \rightarrow Cl_2 + 2e^-$ or balanced with ½ (2) ;	2	$Cl^- \rightarrow Cl_2$ (1) ; adding electrons and balancing (1) ; **ignore** state symbols **allow** $2Cl^- - 2e^- \rightarrow Cl_2$ 2nd mark depends on 1st
		(iv)	$1s^2 2s^2 2p^6 3s^2 3p^5$ (1) ;	1	**allow** upper or lower case letters but numbers **must** be superscripts **allow** [Ne] $3s^2 3p^5$
	(d)	(i)	$Cl_2 = 0$ (1); $Cl^- = -1$ (1) ;	2	**do not allow** 1-
		(ii)	reduction (1) ; gain of electrons / oxidation state has decreased (1) ;	2	**allow** oxidation state becomes more negative **ignore** redox mark independently
		(iii)	chlorine is a more powerful / stronger / better oxidising agent / more oxidising (than bromine). ORA(1) ;	1	**do not allow** chlorine is more reactive than bromine. **allow** chlorine has a higher oxidising ability.
		(iv)	making medicines / making flame retardants (1) ;	1	**allow** water purification, making agricultural chemicals (like bromomethane), making dyes / photography / making solvents. **allow** testing for unsaturation or a stated laboratory use

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	(e)		***must have**:* 1. instantaneous (dipole) – induced dipole bonds (underlined part must be correctly spelt) (1) **;** *plus **four** out of:* 2. electron movements in the molecules create an uneven distribution of charge (1) **;** 3. a dipole is induced in a neighbouring molecule leading to attraction (1) **;** 4. intermolecular bonds are stronger in bromine/Br_2 ORA(1) **;** 5. bromine has more electrons (ORA) (1) **;** 6. more energy / higher temperature is needed to break intermolecular bonds in bromine ORA (1) **;**	**5**	**allow** references to intermolecular forces, rather than intermolecular bonds. 1. **allow** anywhere in answer **allow** van der Waals correctly spelt, ignoring capitals 4. **do not allow** more / higher intermolecular bonds 5. **do not allow** references to electron density. 6. a clear statement referring to breaking the covalent bond in bromine **cons** this point.
			Total	**23**	

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2	(a)	(i)	white (1) ;	1	**do not allow** off white/cream/grey white **ignore** cloudy **ignore** changes of colour on standing
		(ii)	$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ equation (1) ; state symbols (1) ;	2	completely correct equation (i.e. without spectator ions) scores the first mark. **allow** answer with multiples mark state symbols separately – must have the idea of (aq) + (aq) → (s)
		(iii)	Ag_2SO_4 (1) ;	1	**ignore** brackets around SO_4
	(b)	(i)	equilibrium (position) moves to left / towards reactants(1) ; HCO_3^- (concentration) increases(1) ;	2	equilibrium moves to make more HCO_3^- gains both marks
		(ii)	rate of forward reaction = rate of back reaction / reactants and products are formed at the same rate (1) ; concentrations of reactants and products remain constant / closed system (1) ;	2	**do not allow** concentrations of reactants and products are the same / equal
	(c)	(i)	intermolecular bonds in chloromethane are weaker ORA (1) ;	1	answer must be a comparison. **do not allow** less/fewer for weaker **ignore** references to specific types of intermolecular bond

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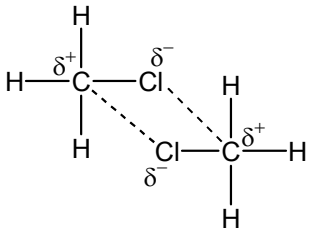
		(ii)	at least one intermolecular bond shown from Cl of one molecule to C of another (1) ; C and Cl of each molecule shown with δ^+/ δ^- charge (1) ; 	2	intermolecular bond can be shown in other forms, but **not** as a solid line. there must be 2 δ^+ on 2 carbons and 2 δ^- on 2 chlorines **ignore** any δ^+/ δ^- on hydrogen.
		(iii)	permanent dipole–(permanent) dipole (1) ;	1	**do not allow** pd-pd
		(iv)	346 x 1000 (=346000) (1) ; answer / 6.02 x 10^{23} = 5.748 x 10^{-19} J (1) ;	2	**allow** 2 or more sig figs
		(v)	answer to (c) (iv) / 6.63 x 10^{-34} (1) ; evaluation of number divided by h (= 8.67 x 10^{14} Hz) (1) ; 3 sf (1) ;	3	award sf mark for an answer that is the correct 3sf value of a shown calculation.
	(d)	(i)	$C_4H_9OH + HCl \rightarrow C_4H_9Cl + H_2O$ (1) ;	1	**allow** answers with other structural forms for butan-1-ol and 1-chlorobutane. **ignore** state symbols
		(ii)	nucleophilic (1) ; substitution (1) ;	2	**allow** answers indicated in other ways, such as circling. each additional underline **cons** a mark
		(iii)	(shaking with) (sodium / potassium) hydrogencarbonate (solution) (1) ;	1	**allow** sodium / potassium hydrogen carbonate **allow** sodium / potassium carbonate

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		(iv)	(anhydrous) sodium sulfate (1) ; or other salt with an anhydrous form	1	**allow** conc. H_2SO_4 / silica gel **allow** correct formula **allow** sulphate
		(v)	M_r butan-1-ol = 74, chlorobutane = 92.5 (1) ; Moles butan-1-ol = 10/74 (=0.135) (1) ; moles chlorobutane = 2/92.5 (=0.022) (1) ; % = 0.022 x 100/0.135 = 16% (1) ; **or** M_r butan-1-ol = 74, chlorobutane = 92.5 (1) ; Moles butan-1-ol = 10/74 (= 0.135) (1) ; 0.135 x 92.5 (= 12.4875) (1) ; % = 2/12.4875 x 100 = 16% (1) ;	4	apply ecf for moles of butan-1-ol / 1-chlorobutane from an incorrect M_r value. **allow** a final answer of between 15.7 to 16.3%, which is obtained if numbers have been rounded at an earlier stage. **allow** 2 or more sf give 1 mark for 2/10x100 = 20%
			Total	**26**	

Question			Expected Answers	Marks	Additional Guidance
3	(a)	(i)	refining oil / generating electricity / processes in a petrochemical plant / producing steel / heating limestone / fermentation (1) **;**	1	**allow** burning a fossil fuel provided it is the context of another industrial activity eg in a factory **allow** making cement **ignore** deforestation
		(ii)	*any **one** pair from*: NO/ NO_2 / NO_x / SO_2 / SO_3 / SO_x (1) **;** causes acid rain / causes breathing problems (1) **;** **or** unburnt hydrocarbons / Carbon monoxide / NO_x (1) **;** causes smog (1) **;** **or** CO_2 / NO_x / C_xH_y (1) **;** causes greenhouse effect / global warming (1) **;** **or** NO_x / SO_x / CO / aromatics (1) **;** causes toxic effects on humans (1) **;**	2	A correct pollutant gas scores the first mark. The second mark depends on the first. **do not allow** harmful instead of toxic

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	(b)		*any **five** from*: (a) UV / visible from the Sun is absorbed by the Earth / heats the Earth(1) **;** (b) Earth radiates/emits IR (1) **;** (c) CO_2 absorbs IR (1) **;** (d) which causes <u>bonds</u> to vibrate (more) (1) **;** (e) more CO_2 means more radiation is absorbed (1) **;** (f) this energy is transferred to KE that increases atmospheric temperature / molecules radiate IR that warms Earth / atmosphere (1) **;** ***QWC** for connection of ideas:* *Earth absorbing radiation or being warmed then Earth emitting radiation* ***or*** *CO_2 absorbs IR then bonds vibrate* ***or*** *CO_2 absorbs IR then energy is transferred to the atmosphere.*	**5** **1**	(a) **do not allow** light or sunlight instead of UV / visible (b) & (c) allow long-wave or low frequency radiation, **do not allow** reflects IR. (c) **allow** answers suggesting other radiations are absorbed by the CO_2 (c) and (e) **allow** 'greenhouse gases' for CO_2
	(c)	**(i)**	the ocean water is too deep to be disturbed by a rock-slide / pressure under the ocean keeps the CO_2 in place(1) **;**	**1**	**allow** rock slides (of this type) don't occur in the ocean.

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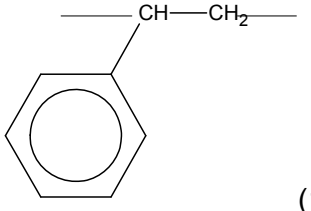
		(ii)	any **two** from: burn less fossil fuel (1) **;** named alternative power source (1) **;** less deforestation / plant more trees (AW) / more photosynthesis (1) **;** reacting the CO_2 with lime/other suitable named solid (1) **;** disposing of it in an old mine / well / other suitable disposal site (1) **;**	2	**do not allow** just fewer cars
			Total	12	

Question			Expected Answers	Marks	Additional Guidance
4	(a)		addition (1) ;	1	**do not allow** additional **ignore** electrophilic and radical. **do not allow** nucleophilic.
	(b)		 (1) ;	1	**ignore** brackets and n **ignore** ambiguous attachments and small errors in benzene structure. **do not allow** more than one simplest repeat unit **allow** more displayed versions
	(c)	(i)	(colour change) red / brown / orange / yellow (1) ; to colourless (1) ;	2	Any combination of these colours but no others **do not allow** "clear" instead of "colourless". answers like 'it turns colourless' gain 1 mark.
		(ii)	carbocation (1) ;	1	**allow** carbonium ion. **allow** minor spelling error **do not allow** bromonium ion
		(iii)	carbocation / intermediate 1 is attacked by nucleophiles / species carrying negative charge / Br^- / $C\ell^-$ (1) ; both Br^- and $C\ell^-$ attack carbocation / intermediate 1 (1) ; attack by Br^- gives compound A / Attack by $C\ell^-$ gives compound B (1) ;	3	**allow** marks from suitable diagrams **allow** 'attract' for 'attack' provided it leads to a reaction.
	(d)	(i)	HBr / hydrogen bromide / hydrobromic acid (1) ;	1	**ignore** state symbols
		(ii)	(partially) positively charged/ electron deficient reagent (AW) (1) ; bonds by accepting a pair of electrons (1) ;	2	**ignore** lone in lone pair

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		(iii)	water / steam (1) ; phosphoric acid catalyst (1) ; high temperature and pressure/300C and 60atm (1) ;	3	**allow** sulfuric acid instead of phosphoric acid **ignore** concentrations **ignore** inert catalyst supports such as alumina **allow** temps 200-400C and pressure above 1atm **do not** give a mark for high temperature and pressure without water/steam
	(e)	(i)	C to which the OH is joined is itself joined to two other Cs / one H on C to which OH is bonded/ 2 alkyl groups on C(1) ;	1	can refer to R groups. **allow** "it" for OH **ignore** OH in middle of chain
		(ii)	*any **four** from:* the oxidation produces a ketone/ propanone (1) ; absorption within 1705 to 1725 (cm^{-1}) (1) ; shows presence of C=O bond (1) ; there is no peak/trough between 3200 to 3640 (cm^{-1}) (1) ; indicating there is no O-H bond (1) ;	4	**allow** 'around/approximately 1700'. **accept** one number from 1705 and 1725 **accept** one number between 3200 and 3640 allow 2 marks for correctly indicating the peak at 1720 due to C=O on the IR spectrum allow 2 marks for indicating that there is no peak at 3200 due to O-H on the IR spectrum **ignore** references to other peaks/troughs
			Total	19	

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5	(a)		*meaning:* splitting / breaking down a chemical / molecule / bond(1) **;** using <u>energy</u> absorbed from UV / visible / light(1) **;** *example:* splitting of a water molecule by UV (radiation) (1) **;**	**3**	The example quoted **must** be the one taken from the article (break-up of water by UV radiation). It can be represented by an equation. the second mark can be scored in either part by mention of hν e.g. on the equation arrow
	(b)		1. formation of oxygen atoms from dissociation of water by UV or dissociation of O_2 by UV / $O_2 \rightarrow 2O$(1) ; 2. oxygen atoms/radicals join to make O_2 / $O+O \rightarrow O_2$ / O_2 formed by photosynthesis (1) ; 3. O_2 plus O gives O_3 / $O_2+O \rightarrow O_3$(1) ; 4. ozone is decomposed / $2O_3 \rightarrow 3O_2$ / $O_3 \rightarrow O_2+O$(1) ; 5. absorbs UV from sunlight (1) ; ***QWC*** *mark for connection of ideas:* *idea of O atoms formed and then being used in another reaction*	**5** **1**	**allow** $H_2O \rightarrow H_2 + O$ / $H_2O \rightarrow 2H + O$ UV or hν not needed. **allow** 'photodissociation' instead of 'by UV'. for full marks at least one of marking points 2, 3 and 4 **must** be given as an equation. **allow** frequency values in the range 1×10^{15} to 1×10^{17} Hz instead of UV. mark independently
	(c)		converting both values to the same units (2 ppm = 0.0002% / 20.948% = 209480 ppm) (1) **;** dividing oxygen value by methane value (20.948/0.0002 or 209480/2 = 104740) (1) **;**	**2**	**allow** 3 sf or more mark independently

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(d)	FeS_2 is oxidised (1) ; O_2 and Fe_2O_3/FeO/Fe_3O_4 in an equation (1) ; completely correct equation (1) ; $4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$ $3FeS_2 + 8O_2 \rightarrow Fe_3O_4 + 6SO_2$ $FeS_2 + 2.5O_2 \rightarrow FeO + 2SO_2$	3	
(e)	the temperature in the troposphere decreases as you move away from the Earth's surface (1) ; because hot gases near the Earth's surface rise & cool / higher concentrations of greenhouse gases / named gas lower down absorb more IR from Earth / the atmosphere is heated by the Earth low down(1) ; within the stratosphere the temperature of the atmosphere rises as you move away from the Earth (1) ; due to exothermic reactions (1) ;	4	mark independently candidates can give figures for altitudes instead of troposphere / stratosphere
(f)	the concentration of gases is higher in the troposphere / troposphere is more dense / pressure is higher ORA (1) ; so there are more collisions per second / more frequent collisions (in the troposphere) (1) ;	2	**do not allow** 'more collisions' or 'more chance of collisions'
	Total	**20**	