

# Markscheme

**May 2019**

**Chemistry**

**Standard level**

**Paper 3**

27 pages

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Section A

Question			Answers	Notes	Total
1.	a		6 ✓	Accept "orange juice".	1
1.	b	i	equilibrium is being established «between lead in solution and in mug» <b>OR</b> solution becoming saturated <b>OR</b> concentration of lead ions/[Pb <sup>2+</sup> ] has increased «over time» <b>OR</b> acid concentration has decreased «as reacted with lead» <b>OR</b> surface lead has decrease/formed a compound/forms insoluble layer on surface <b>OR</b> acid reacts with other metals «because it is an alloy» ✓	Do <b>not</b> accept "concentration of cola, orange juice, etc... has decreased".  Do <b>not</b> accept responses that only discusses mathematical or proportional relationships.	1
1.	b	ii	no <b>AND</b> experiment 7/beer has lowest rate and intermediate acidity/pH <b>OR</b> no <b>AND</b> experiment 6/orange juice has fastest rate but lower acidity/higher pH than experiment 5/lemonade <b>OR</b> no <b>AND</b> experiment 6/orange juice has highest rate and intermediate acidity/pH ✓	Accept no <b>AND</b> any comparison, <b>with experimental support</b> , that concludes no pattern/increase with acidity.  eg: "rate of Pb/lead dissolving generally decreases with acidity as tap water has highest rate (after orange juice) while lemonade (lower pH) has lower rate".	1

Question			Answers	Notes	Total
1.	c	i	equilibrium shifts to the left/towards reactants ✓  lead «compounds/ions» precipitate <b>OR</b> concentration of lead «ions»/[Pb <sup>2+</sup> ] decreases ✓	Award <b>[2]</b> for “equilibrium shifts to the left/towards reactants due to common ion effect”. Accept “lead ions/[Pb <sup>2+</sup> ] removed from solution” for M2.	2
1.	c	ii	«daily limit = $5.0 \times 10^{-6} \text{ g kg}^{-1} \times 80.0 \text{ kg} \Rightarrow 4.0 \times 10^{-4} \text{ «g of lead»}$ ✓  «volume = $\frac{4.0 \times 10^{-4} \text{ g}}{1.5 \times 10^{-2} \text{ g dm}^{-3}} \Rightarrow 2.7 \times 10^{-2} / 0.027 \text{ «dm}^3\text{»}$ ✓	Award <b>[2]</b> for correct final answer.	2





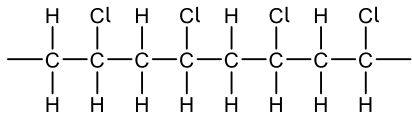
**Section B**

**Option A — Materials**

Question	Answers	Notes	Total
3.	<p><i>Shape of molecules:</i> linear <b>OR</b> rod «shaped» ✓</p> <p><i>Distribution:</i> no positional order <b>AND</b> «some» directional order ✓</p> <p><i>Effect of electric field:</i> «directional» order increases <b>OR</b> molecules align in same direction ✓</p>	<p><i>Accept “partly ordered”.</i></p>	<p><b>3</b></p>

Question		Answers	Notes	Total
4.	a	moles of electrons $\llcorner = \frac{48\,250\text{ C}}{96\,500\text{ C mol}^{-1}} \llcorner = 0.5000\text{ «mol»} \checkmark$ moles of aluminium $\llcorner = \frac{0.5000\text{ mol}}{3} \llcorner = 0.1667\text{ «mol»} \checkmark$ mass of aluminium $\llcorner = 26.98\text{ g mol}^{-1} \times 0.1667\text{ mol} \llcorner = 4.50\text{ «g»} \checkmark$	<i>Award [3] for correct final answer.</i>	3
4.	b	<i>Any two of:</i> larger linear calibration $\checkmark$ «accurate» detection of multiple elements/metals $\checkmark$ «accurate» detection of elements in low concentration $\checkmark$ temperature around 10 000 K atomises/ionises every material $\checkmark$		2 max
4.	c	<i>Any two of:</i> reactant(s) adsorb onto active sites/surface $\checkmark$ bonds weakened/broken/stretched «in adsorbed reactants» <b>OR</b> activation energy lowered $\checkmark$ products desorbed $\checkmark$	<i>Accept “products released” for M3.</i>	2 max
4.	d	<i>Conduct electricity:</i> «delocalized/valence» electrons free to move «under potential difference» $\checkmark$  <i>Harder than pure metals:</i> atoms/ions of different sizes prevent layers «of atoms/ions» from sliding over one another $\checkmark$		2
4.	e	$2\text{CO (g)} \rightarrow \text{C (s)} + \text{CO}_2\text{ (g)} \checkmark$		1



Question		Answers	Notes	Total
5.	a	 <p>correct bonding ✓ Cl atoms all on same side and alternate ✓</p>	<p><i>Continuation bonds must be shown.</i> <i>Award [1 max] if less than or more than four units shown.</i> <i>Accept a stereo formula with all atoms and bonds shown.</i></p>	2
5.	b	«strong additional» absorption at 600–800 «cm <sup>-1</sup> » ✓		1
5.	c	<p>Any one of:</p> <p>HCl ✓ Cl<sub>2</sub> ✓ dioxins ✓ C ✓ CO ✓</p>	Accept names or formulas.	1 max
5.	d	<p>Any two of:</p> <p>embedded/fit between chains of polymers ✓ prevent chains from forming crystalline regions ✓ keep polymer strands/chains/molecules separated/apart ✓ increase space/volume between chains ✓ weaken intermolecular/dipole-dipole/London/dispersion/instantaneous dipole-induced dipole/van der Waals/vdW forces «between chains» ✓ increase flexibility/durability/softness ✓ make polymers less brittle ✓</p>	Accept “lowers density/melting point”.	2 max
5.	e	<p>leach into foodstuffs/environment <b>OR</b> «unknown» health/environmental consequences ✓</p>	Accept “plasticizers cannot be recycled”.	1

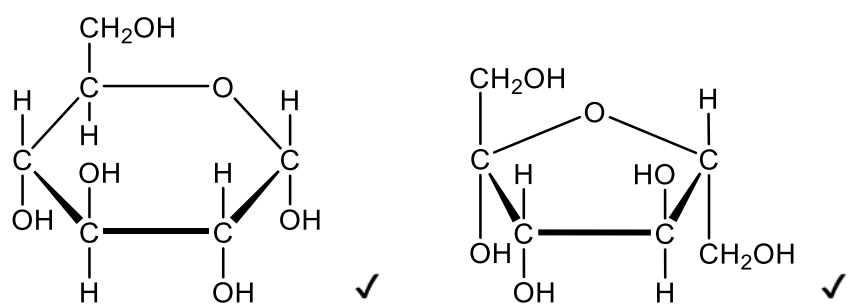
Option B — Biochemistry

Question			Answers	Notes	Total
6.	a	i	$\beta$ /beta pleated/sheet ✓		1
6.	a	ii	<p><i>One similarity:</i> hydrogen bonding <b>OR</b> attractions between C=O and N-H ✓</p> <p><i>One difference:</i> <math>\alpha</math>-helix has hydrogen bonds between amino acid residues that are closer than <math>\beta</math>-pleated sheet <b>OR</b> H-bonds in <math>\alpha</math>-helix parallel to helix axis <b>AND</b> perpendicular to sheet in <math>\beta</math>-pleated sheet <b>OR</b> <math>\alpha</math>-helix has one strand <b>AND</b> <math>\beta</math>-pleated sheet has two «or more» strands <b>OR</b> <math>\alpha</math>-helix is more elastic «since H-bonds can be broken easily» <b>AND</b> <math>\beta</math>-pleated sheet is less elastic «since H-bonds are difficult to break» ✓</p>	<p><i>Accept a diagram which shows hydrogen bonding between O of C=O and H of NH groups for M1.</i></p> <p><i>Accept “between carbonyl/amido/amide/carboxamide” but not “between amino/amine” for M1.</i></p>	2
6.	b		<p>enzyme denatured/loss of 3-D structure/conformational change <b>OR</b> «interactions responsible for» tertiary/quaternary structures altered ✓</p> <p>shape of active site changes <b>OR</b> fewer substrate molecules fit into active sites ✓</p>		2

Question			Answers	Notes	Total
6.	c	i	<p><i>Any two of:</i></p> <p>surface water is warmer «so faster reaction rate»/more light/energy from the sun ✓</p> <p>more oxygen «for aerobic bacteria/oxidation of oil» ✓</p> <p>greater surface area ✓</p>		2 max
6.	c	ii	<p><i>Any one of:</i></p> <p>non-hazardous/toxic to the environment/living organisms ✓</p> <p>energy requirements «during production» ✓</p> <p>quantity/type of waste produced «during production»</p> <p><b>OR</b></p> <p>atom economy ✓</p> <p>safety of process ✓</p>	<p><i>Accept "use of solvents/toxic materials «during production»".</i></p> <p><i>Do <b>not</b> accept "more steps involved".</i></p>	1 max

Question			Answers	Notes	Total
7.	a	i	$  \begin{array}{c}  \text{O} \\  \parallel \\  \text{H}_2\text{C}-\text{O}-\text{P}-\text{O}-\text{CH}_2-\text{CH}_2-\text{N}^+(\text{CH}_3)_3 \\    \\  \text{O}^- \\  \\  \text{HC}-\text{O}-\text{C}-(\text{CH}_2)_{10}\text{CH}_3 \\    \\  \text{O} \\  \\  \text{H}_2\text{C}-\text{O}-\text{C}-(\text{CH}_2)_{10}\text{CH}_3 \\    \\  \text{O}  \end{array}  $ <p>phosphodiester correctly drawn ✓ both ester groups correctly drawn ✓</p>	<p>Accept protonated phosphate. Accept phosphodiester in centre position.</p>	2
7.	a	ii	condensation ✓	<p>Accept "esterification". Accept "nucleophilic substitution/S<sub>N</sub>".</p>	1

Question		Answers	Notes	Total
7.	b	phospholipid bilayer/double layer <b>OR</b> two layers of phospholipids ✓  polar/hydrophilic heads facing aqueous environment <b>AND</b> non-polar/hydrophobic tails facing away from aqueous environment ✓	Award <b>[2]</b> for a suitably labelled diagram.  Award <b>[1 max]</b> for a correct but unlabelled diagram.  Accept "polar/hydrophilic heads on outside <b>AND</b> non-polar/hydrophobic tails on inside for M2.	2
7.	c	carbohydrates less energy dense <b>AND</b> carbohydrates higher ratio of oxygen to carbon/more oxidized/less reduced ✓		1
7.	d	long non-polar/hydrocarbon chain «and only one hydroxyl group» <b>OR</b> forms London/dispersion/van der Waals/vdW interactions with fat ✓	Accept "alcohol/hydroxy/OH" for "hydroxyl" but <b>not</b> "hydroxide".	1
7.	e	atherosclerosis/cholesterol deposition «in artery walls» ✓ increases risk of heart attack/stroke/cardiovascular disease/CHD ✓	Accept "arteries become blocked/walls become thicker", "increases blood pressure", or "blood clots".  Do <b>not</b> accept "high cholesterol".	2

Question			Answers	Notes	Total
8.	a		acetal <b>OR</b> ether ✓	Accept "glycosidic bond/linkage" but <b>not</b> "glucosidic".  Do <b>not</b> accept "hemiacetal".	1
8.	b				2

Option C — Energy

Question	Answers	Notes	Total
9.	<p><b>Advantage</b>  <i>Any one of:</i>                      renewable ✓                      predictable supply ✓                      tidal barrage may prevent flooding ✓                      effective at low speeds ✓                      long life-span ✓                      low cost to run ✓</p> <p><b>Disadvantage</b>  <i>Any one of:</i>                      cost of construction ✓                      changes/unknown effects on marine life ✓                      changes circulation of tides in the area ✓                      power output is variable ✓                      limited locations where feasible ✓                      equipment maintenance can be challenging ✓                      difficult to store energy ✓</p>	<p><i>Do not accept vague generalizations.</i></p> <p><i>Do not accept economic issues for both advantage and disadvantage.</i></p> <p><i>Do not accept sustainable.</i></p> <p><i>Accept “energy” or “electricity” for “power”.</i></p>	2 max

Question		Answers		Notes	Total
10.	a	<p><b>Fractional distillation:</b></p> <p>Any two of: <b>1 max</b></p> <p>physical process</p> <p>separation of compounds by boiling point/vapor pressure</p> <p>breaking intermolecular forces</p> <p>different molar masses</p> <p>does not use catalyst</p>	<p><b>Cracking:</b></p> <p>Any two of: <b>1 max</b></p> <p>chemical process</p> <p>new compounds formed</p> <p>increasing branching/aromatic ring formation</p> <p>short hydrocarbon chains formed</p> <p>breaking «and remaking»/changing covalent bonds</p> <p>uses catalyst</p>	<p>Award <b>[1 max]</b> for any two correct answers from one column <b>OR</b> one from each column.</p> <p>Award <b>[2]</b> for any two correct from each column; eg: fractional distillation – any two correct award <b>[1 max]</b> <b>AND</b> cracking – any two correct award <b>[1 max]</b>.</p>	2 max
		<p>specific energy = « <math>\frac{4163 \text{ kJ mol}^{-1}}{86.2 \text{ g mol}^{-1}}</math> » ⇒ 48.3 «kJ g<sup>-1</sup>» ✓</p> <p>energy density = «48.3 kJ g<sup>-1</sup> × 0.660 g cm<sup>-3</sup> » ⇒ 31.9 «kJ cm<sup>-3</sup>» ✓</p>		<p>Award <b>[1 max]</b> if either or both answers not expressed to three significant figures.</p>	



Question		Answers	Notes	Total
10.	c	<p>Any two of:</p> <p>«hydrocarbons are heated with» catalyst ✓</p> <p>long chains break and reform</p> <p><b>OR</b></p> <p>branching/aromatization occurs</p> <p><b>OR</b></p> <p>isomerisation/reforming/platforming/cracking ✓</p> <p>zeolite separates branched from non-branched</p> <p><b>OR</b></p> <p>products are distilled</p> <p><b>OR</b></p> <p>«distillation» separates reformed and cracked products ✓</p>	<p>Accept a specific catalysis name or formula for M1 such as Pt/Re/Rh/Pd/Ir.</p>	<p>2 max</p>

Question			Answers	Notes	Total
11.	a	i	$^{103}_{40}\text{Zr}$ ✓		1
11.	a	ii	minimum mass to «self-»sustain chain reaction <b>OR</b> if mass of fissile material is too small, too many neutrons produced pass out of the nuclear fuel <b>OR</b> at least one neutron produced causes further reaction ✓		1
11.	a	iii	Any one of: reduction in emission of greenhouse gases «from burning fossil fuels» ✓ economic independence/self-sufficiency «from crude oil/producing states» ✓ uranium is more abundant on Earth «in terms of total energy that can be produced from this fuel» than fossil fuels ✓	Accept specific greenhouse gases (such as carbon dioxide/CO <sub>2</sub> ) but not pollutants or other general statements.	1 max
11.	b		Any one of: fuel is inexpensive/readily available ✓ no/less radioactive waste is formed ✓ lower risk of accidents/large-scale disasters ✓ impossible/harder to use for making materials for nuclear weapons ✓ larger amounts of energy released per unit mass ✓ does not require a critical mass ✓ can be used continuously ✓	Accept “higher specific energy for fusion”.  Do <b>not</b> accept “no/less waste produced for fusion”.  Accept specific example for disasters.	1 max
11.	c		86.4 «years» ✓		1

Question			Answers	Notes	Total
12.	a		large/extensive «electronic» conjugation <b>OR</b> «contains» many alternate single and double bonds <b>OR</b> extended system of alternating double and single bonds ✓	<i>Student response must indicate a large or extended system to award mark.</i>	1

Question		Answers	Notes	Total
12.	b	<p><b>Strength</b> Any one of: less flammable «than diesel» ✓  recycles carbon «lower carbon footprint» <b>OR</b> lower greenhouse gas emissions ✓  easily biodegradable «in case of spill» ✓  renewable <b>OR</b> does not deplete fossil fuel reserves ✓  economic security/availability in countries without crude oil ✓</p> <p><b>Limitation</b> Any one of: more difficult to ignite inside the engine «than diesel» ✓ more viscous «than diesel» ✓ lower energy content/specific energy/energy density ✓  uses food sources <b>OR</b> uses land that could be used for food ✓  «production is» more expensive ✓ less suitable in low temperatures ✓ increased NO<sub>x</sub> emissions for biodiesel ✓ greenhouse gases still produced ✓</p>	<p>Accept “«close to» carbon neutral”, “produce less greenhouse gases/CO<sub>2</sub>”.</p> <p>Accept “engines have to be modified if biodiesel used” as limitation.</p> <p>Do <b>not</b> award marks for strength and limitation that are the same topic/concept.</p>	2 max

Question		Answers	Notes	Total
13.	a	<p>Any one of: methane, water, nitrous oxide/nitrogen(I) oxide, ozone, CFCs, sulfur hexafluoride ✓</p>	<p>Accept formulas. Do <b>not</b> accept "NO<sub>2</sub>", "NO<sub>x</sub>", "oxides of sulfur".</p>	1 max
13.	b	<p>bond length/C=O distance changes <b>OR</b> «asymmetric» stretching «of bonds» <b>OR</b> bond angle/OCO changes ✓</p> <p>polarity/dipole «moment» changes <b>OR</b> dipole «moment» created «when molecule absorbs IR» ✓</p>	<p>Accept appropriate diagrams.</p>	2
13.	c	<p>Any one of: capture where produced «and stored» ✓ use scrubbers to remove ✓ use as feedstock for synthesizing other chemicals ✓ carbon credit/tax/economic incentive/fines/country specific action ✓</p> <p>use alternative energy <b>OR</b> stop/reduce use of fossil fuels for producing energy ✓</p> <p>use carbon reduced fuels «such as methane» ✓ increase efficiency/reduce energy use ✓</p>	<p>Do <b>not</b> accept "planting more trees". Accept specific correct examples.</p>	1 max

Option D — Medicinal chemistry

Question			Answers	Notes	Total
14.	a		<p><i>Therapeutic window:</i> range of dosage «over which a drug» provides the therapeutic/desired effect without causing adverse/toxic effects ✓</p> <p><i>Therapeutic index:</i> toxic dose of drug for 50 % of population divided by minimum effective dose for 50 % of population</p> <p><b>OR</b></p> $\frac{TD50}{ED50} \checkmark$	<p><i>M1 may be scored from a correctly labelled diagram.</i></p> <p><i>Accept “difference between ED50/minimum effective/therapeutic dose «for 50 % of population» <b>AND</b> TD50/toxic dose «for 50 % of population»” for M1.</i></p> <p><i>Do <b>not</b> accept reference to lethal dose used in therapeutic index in animal studies.</i></p>	2
14.	b	i	<p>blocks pain impulses/binds with «opioid» receptors in <u>brain/CNS</u></p> <p><b>OR</b></p> <p>effective against strong pain</p> <p><b>OR</b></p> <p>sedate patients to reduce trauma ✓</p>	<p><i>Accept “effective against pain after surgery/cancer/following serious injury”.</i></p> <p><i>Accept “relieves anxiety/stress associated with severe/terminal illness”.</i></p>	1

(continued...)

(Question 14b continued)

Question			Answers	Notes	Total
14.	b	ii	<p>morphine has «two» hydroxyl groups <b>AND</b> diamorphine has «two» ester/ethanoate/acetate groups</p> <p><b>OR</b></p> <p>molecule of diamorphine is less polar than morphine</p> <p><b>OR</b></p> <p>groups in morphine are replaced with less polar/non-polar groups in diamorphine ✓</p> <p>«less polar molecules» cross the blood–brain barrier faster/more easily</p> <p><b>OR</b></p> <p>diamorphine is more soluble in non-polar environment of CNS/central nervous system than morphine ✓</p>	<p>Accept “alcohol/hydroxy” for “hydroxyl” but <b>not</b> “hydroxide”.</p> <p>Accept “fats” for “lipid”.</p> <p>Accept “heroin” for “diamorphine”.</p>	2
15.	a		<p>Any one of:</p> <p>1050–1410 «cm<sup>-1</sup> due to C–O» ✓</p> <p>1700–1750 «cm<sup>-1</sup> due to C=O in acids and esters» ✓</p> <p>2500–3000 «cm<sup>-1</sup> due to O–H in acids» ✓</p> <p>2850–3090 «cm<sup>-1</sup> due to C–H in alkanes and arenes» ✓</p>		1 max

Question			Answers	Notes	Total
15.	b	i	$n(\text{aspirin}) \llcorner n(\text{NaOH}) = \frac{16.25 \text{ cm}^3}{1000} \times 0.100 \text{ mol dm}^{-3} \llcorner = 1.625 \times 10^{-3} \llcorner \text{mol} \llcorner \checkmark$ $m(\text{aspirin}) \llcorner 1.625 \times 10^{-3} \text{ mol} \times 180.17 \text{ g mol}^{-1} \llcorner = 0.293 \llcorner \text{g} \llcorner \checkmark$	<i>Award [2] for correct final answer.</i>	2
15.	b	ii	$\llcorner \frac{0.293 \text{ g}}{0.300 \text{ g}} \times 100 \% \llcorner = 97.7 \llcorner \% \llcorner \checkmark$		1
15.	c		convert to a salt <b>OR</b> react with sodium hydroxide/NaOH $\checkmark$	<i>Accept other reactions forming soluble salts.</i>  <i>Accept "to ionize" but <b>not</b> "more polar".</i>	1
15.	d		synergistic effect/increased toxicity <b>OR</b> increased risk of stomach/intestines bleeding/ulcers/heartburn <b>OR</b> increased risk of liver toxicity/damage <b>OR</b> increased risk of nausea/vomiting $\checkmark$		1
15.	e		<i>Any two of:</i> energy requirements «during production» $\checkmark$ use of toxic materials «during production» $\checkmark$ use of solvents «that are not recycled» $\checkmark$ emission of toxic by-products $\checkmark$  quantity of waste produced <b>OR</b> atom economy $\checkmark$	<i>Accept "E-factor/carbon efficiency/% of carbon in reactants vs products" for M1.</i>  <i>Accept references to materials being/not being recycled for M3.</i>	2 max



Question			Answers	Notes	Total
16.	a	i	blocks/binds H <sub>2</sub> /histamine receptors «in cells of stomach lining» <b>OR</b> prevents histamine molecules binding to H <sub>2</sub> /histamine receptors «and triggering acid secretion» ✓		1
16.	a	ii	<i>Any two of:</i> ranitidine can be effective in treating ulcers «but antacid is not» ✓ ranitidine can prevent long-term damage «from overproduction of acid and antacid does not» ✓ ranitidine has a long-term effect «and antacid has short-term effect only» ✓ ranitidine does not affect ionic balance in body «and antacid does» ✓ ranitidine does not produce bloating/flatulence ✓	<i>Accept “ranitidine stops the over production of acid in the stomach while antacids neutralize the excess acid giving temporary relief”.</i>	2 max
16.	b		«pH = pK <sub>a</sub> + log $\frac{[A^-]}{[HA]}$ = 10.32 + log $\frac{0.160}{0.200}$ = 10.32 - 0.097» «pH =»10.22 ✓		1

Question		Answers	Notes	Total
17.	a	<p>Any one of:</p> <p>alter cell's genetic material «so that virus cannot use it to multiply» ✓</p> <p>prevent viruses from multiplying by blocking enzyme activity within host cell</p> <p><b>OR</b></p> <p>inhibit the synthesis of viral components by blocking enzymes inside the cell ✓</p> <p>prevent viruses from entering «host» cell</p> <p><b>OR</b></p> <p>bind to cellular receptors targeted by viruses</p> <p><b>OR</b></p> <p>bind to virus-associated proteins/VAPs which target cellular receptors</p> <p><b>OR</b></p> <p>prevents removal of protein coat/capsid</p> <p><b>OR</b></p> <p>prevents injection of viral DNA/RNA into cell ✓</p> <p>prevent/hinder the release of viruses from the cell ✓</p>	<p>Accept "prevents synthesis of virus by host cell".</p> <p>Accept "alters RNA/DNA/genetic material of virus".</p> <p>Do <b>not</b> accept just "mimics nucleotides".</p>	1 max

Question		Answers	Notes	Total
17.	b	<p><i>Any two of:</i></p> <p>viruses lack cell structure «so difficult to target with drugs» ✓</p> <p>HIV is a retrovirus</p> <p><b>OR</b></p> <p>HIV genetic material is in the form of RNA instead of DNA ✓</p> <p>HIV affects/destroys helper/T-cells which are necessary to fight infection ✓</p> <p>HIV has great genetic diversity so difficult to produce «a» vaccine ✓</p> <p>anti-retroviral agents are expensive so not everyone/country can afford them ✓</p> <p>socio-cultural issues deter people from seeking treatment/prevention/diagnosis</p> <p><b>OR</b></p> <p>lack of education/conversation/stigma associated with being HIV-positive ✓</p> <p>mutation of virus/HIV ✓</p> <p>virus/HIV metabolism linked to that of host cell ✓</p> <p>drugs harm host cell as well as virus/HIV ✓</p> <p>HIV difficult to detect/remains dormant ✓</p>		2 max