Question			Expected Answer	Mark	Additional Guidance
1	(a)	(i)			**IGNORE** explanations **ACCEPT** 'the population grows' or 'it grows' (rather than increase) **DO NOT CREDIT** 'yeast grow(s)'
			1 lag phase / slow increase (in , population / number / percentage) , at start / initially / day 0 - 1 / during day 1 ;		**1** **ACCEPT** days 0 - 0.9 **ACCEPT** lasts 1 day
			2 log phase / exponential increase / rapid increase , day 1 - 3 ;		**2** **ACCEPT** days 0.9 - 3.5
			3 <u>rate</u> of <u>increase</u> , slows / less steep , days 3 - 4 / during day 3 ;		**3** **ACCEPT** days 3.3 - 3.6
			4 stationary phase / population levels off / population stays at 100% , at end / finally / remaining days / days 4 - 6 ;		**4** **ACCEPT** after day 3.5 - 4
			5 comparative figures quoted with 2 x-y readings ;		**5** Each unit must be quoted at least once

Time (days)	Yeast (% final population)
0	24
1	32
3	90
3.5 - 6	100

Take care to distinguish between an increase in percentage (by either quoting the figures for the days or by calculating the difference) and a *percentage increase*.

4 max

	Question		Expected Answer	Mark	Additional Guidance
1	**(a)**	**(ii)**			**CREDIT** glucose / maltose / maltotriose for 'sugar'
			1 sugar converted to ethanol **;**		
			2 in <u>anaerobic</u> <u>respiration</u> **;**		**2** **IGNORE** fermentation
			3 sugar **,** undergoes glycolysis / converted to pyruvate **;**		
			4 pyruvate **,** loses carbon dioxide / decarboxylated / forms ethanal **;**		
			5 reduced NAD giving hydrogen to <u>ethanal</u> **;**		**5** **CREDIT** $NADH_2$ / $NADH (+H^+)$ / red NAD
			6 *idea of* NAD being **,** regenerated / recycled **,** (so) glycolysis continues **;**		
			7 correct ref to **,** pyruvate decarboxylase / ethanol dehydrogenase **;**	**3 max**	
1	**(a)**	**(iii)**	*ethanol is* produced in **, all** yeast growth phases / **all** of the time **or** production of ethanol increases as yeast population increases **or** *idea that* ethanol is a normal (metabolic waste) product (of yeast) **;**	**1**	**IGNORE** ref to ethanol not being a secondary product **CREDIT** 'produced during normal growth' **CREDIT** follows growth curve for yeast **IGNORE** waste unqualified

Question			Expected Answer	Mark	Additional Guidance
1	(a)	(iv)	**1** sugar <u>concentration</u> falls **too** low ;		**1** **ACCEPT** very low sugar concentration / sugar concentration decreases as used up
			2 pH falls **too** low / conditions become **too** acidic / decrease in pH causes enzymes to denature ;		**2** **ACCEPT** very low pH / very acidic **DO NOT CREDIT** 'falls and rises'
			3 high ethanol <u>concentration</u> , damages / poisons / inhibits , yeast ;	**2 max**	**3** **ACCEPT** high ethanol <u>concentration</u> kills yeast
1	(b)				**ACCEPT** 'monosaccharide' for glucose and 'disaccharide' for maltose and 'trisaccharide' for maltotriose throughout
			1 glucose can , be used / enters glycolysis , directly / without being broken down (first) ;		**1** **IGNORE** ref to glucose being used first / at start / immediately (as stated in Q)
			2 maltose**,** must **,** be <u>hydrolys</u>ed / have <u>glycosidic</u> bonds broken ;		
			3 enzyme / maltase **,** only made when , needed / maltose present / glucose running out ;		
			4 enzyme induced **/** gene(s) switched on ;		
			5 <u>transcription</u> <u>and</u> translation / protein synthesis **,** takes time ;		
			6 maltotriose requires, more (2) <u>hydrolysis</u> (reactions) / breaking of more (2) <u>glycosidic</u> bonds **or** enzyme to break down maltotriose made last ;	**3 max**	

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Question			Expected Answer	Mark	Additional Guidance
1	**(c)**				**CREDIT** statements relating to yeast method only **IGNORE** statements relating to chemical method **IGNORE** ref to cost

			advantages of using yeast
			A1 less energy required **;**
			A2 does not need **,**
			                high temperature / 300°C / high pressure **;**
			A3 can use waste material (as a substrate) **;**
			A4 substrate is **,** sustainable / grown each year **;**
			A5 process does not use up **,** oil reserves / fossil fuels **;**
			A6 product is carbon neutral / no carbon footprint **;**
			A7 AVP **;**
					A2 **ACCEPT** works well at low **,**
					                temperatures / pressures
					A3 **CREDIT** example e.g. sugar cane waste
					
					A6 **IGNORE** ref to global warming / greenhouse gases
					A7 e.g. yeast is readily available / easily accessible /
					            yeast is in plentiful supply /
					            yeast has simple growth requirements /
					            process is less hazardous

			disadvantages of using yeast **D1** time consuming / takes several days **;** **D2** needs **,** downstream processing / purification of product **;** **D3** is killed by product **;** **D4** can (only) use batch method **;** **D5** aseptic / sterile **,** conditions required **;** **D6** AVP **;**	**5 max**	**D1** **ACCEPT** slower rate of reaction **D2** **ACCEPT** need to separate ethanol from yeast **D3** **ACCEPT** is inhibited by product **D5** **ACCEPT** more likely to become contaminated **D6** e.g. concentration of ethanol produced is limited
			QWC **;**	**1**	**Award** if 2 **A** marks **and** 2 **D** marks have been awarded **Place a tick or a cross alongside the pencil icon to indicate whether or not the QWC mark has been awarded.**
			Total	**19**	

Question			Answer	Marks	Guidance
2	**(a)**		reduce / slow, flow rate **;** repeat process / run milk through again **;** test for (named) sugars in milk **;**	2	**ACCEPT** close tap for a time period **CREDIT** glucose, galactose, lactose, Benedict's test
	(b)	**(i)**	*any two from* hydrophobic / ionic bond, to (named), solid / support **;** covalent bond / cross-link to**,** (named) substance**;** membrane separation **;** (en)trap / encapsulate / suspend, in (named), matrix **;**	2	**Mark as prose.** **IGNORE** ref to cross-linking agents **ACCEPT** 'insoluble material for solid. Suitable solids = clay, carbon, resin, glass, gold, ceramic beads. **CREDIT** <u>ad</u>sorption (but not absorption) **CREDIT** carrier bound. **CREDIT** cross-link them together. Suitable substances = other enzymes, collagen, cellulose. **ACCEPT** microcapsules Suitable matrix materials = collagen, cellulose, silica gel, hydrogel, but **DO NOT CREDIT** entangled / alginate
		(ii)	**1** (enzyme) can be re-used so reduces cost **;** **2** product**,** pure(r) / uncontaminated **;** **3** reduced downstream processing costs **;** **4** (immobilised enzyme) works at high(er) temperature **;** **5** (immobilised enzyme) works in changed pH **;** **6** reaction, can be faster / have higher yield , because can be done at higher temperature **;**	4	 **2 ACCEPT** product not mixed with enzyme **3 ACCEPT** save money on purifying product **4 CREDIT** enzymes not denaturing at increased temperature **CREDIT** immobilised enzymes thermostable **5 CREDIT** enzymes not denaturing in changed pHs **6** This explanation scores mp 4 and mp 6 (unless mp 4 already awarded).
			Total	**8**	

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Question			Answer	Marks	Guidance
3	**(a)**		**P** lag ; **Q** log(arithmic) / exponential ; **R** stationary ;	3	**Mark the first answer on each prompt line.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **IGNORE** plateau
	(b)		(molecule made in or needed for cell's normal) survival / function / growth / development / reproduction ; named example ;	2	**IGNORE** metabolism (as stated in Q) / phase e.g. glucose / sucrose / (named) amino acid / CO_2 / ethanol / (named) nucleotide / named named respiratory intermediate / (named) protein / (named) enzyme **DO NOT CREDIT** antibiotics
	(c)	**(i)**	Q ;	1	**Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **ACCEPT** log / exponential
	(c)	**(ii)**	R ;	1	**Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **ACCEPT** stationary
	(c)	**(iii)**	R / S ;	1	**Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **ACCEPT** stationary / decline / death (phase)

	Question		Answer	Marks	Guidance

3	(d)	(i)	<table><tr><td>*factor (F)*</td><td>*change needed (C)*</td></tr><tr><td>oxygen ;</td><td>increase it / more / high
			or
			stir / sparging ;</td></tr><tr><td>(named) nutrient ;</td><td>increase it / more / high
			or
			stir ;</td></tr><tr><td>temperature ;</td><td>maintain at / control at / change to , optimum
			or
			cool
			or
			ref. to using water jacket ;</td></tr><tr><td>pH ;</td><td>maintain at / control at / change to, optimum
			or
			add, buffer / acid / alkali ;</td></tr><tr><td>(waste) product / gas / CO_2 ;</td><td>harvest / remove / waste gas vent ;</td></tr><tr><td>other / unwanted / harmful / competing , microbes ;</td><td>prevent entry / asepsis ;</td></tr></table>
				4	**Mark the first suggestion on each prompt line.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**
					C CREDI *idea of* paddles distributing the available oxygen more evenly
					C ACCEPT continuous, adding / supply, of oxygen
					IGNORE aeration as named **F** but **ACCEPT** for **C**
					C CREDIT *idea of* paddles distributing the available nutrients more evenly
					C ACCEPT continuous, adding / supply, of nutrients
					IGNORE food as named **F** but **ACCEPT** for **C**
					
					C ACCEPT 'suitable' for 'optimum' temperature
					   ACCEPT prevent overheating / enzymes denaturing
					
					C ACCEPT 'suitable' for 'optimum' pH
					   ACCEPT prevent enzymes denaturing
					
					C CREDIT reduce pressure (for waste gases)
					
					F CREDIT named microbes e.g. bacteria / fungi / pathogens
					C CREDIT idea of use of filters or aseptic techniques

Question			Answer	Marks	Guidance
3	(d)	(ii)		3	**ACCEPT** reverse reasoning throughout e.g. **1** in gene therapy **,** the person's cells are altered / a functional allele is introduced.
			1 (child's) cells / DNA / genes / alleles **,** not changed **;**		**1** **DO NOT ACCEPT** gene replacement **ACCEPT** genotype
			2 vector not used (in child) **;** **3** child / cells **,** not producing **,** HGH / hormone **;**		**2** **CREDIT** named vector **3** **CREDIT** (the) protein / polypeptide

			4 HGH / drug / injection **,**
			          has to be given repeatedly /
			          is a short term solution / not a cure **;**		

			Total	**15**	

Question			Answer	Marks	Guidance
4	**(a)**		C ; D ; B ; A ;	4	**Mark the first answer on each prompt line.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**
4	**(b)**		goal D ; A ; B ; C ; E ;	5	**Mark the first answer in each box.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**
			Total	**9**	

Question			Answer	Mark	Guid
5	(a)		DNA (combined) from **(**two) **,** sources / organisms **;**	1	**ACCEPT** DNA, contains / has inserted in it, DNA or gene from, other / another, organism / species **ACCEPT** foreign for idea of other source
	(b)			4	**FA in each box** **DO NOT CREDIT** microinjection / electroporation / gene gun (as they are not vectors)

(b) table:

application of genetic modification	vector	
goats making spider silk protein	BAC / YAC / virus / liposome	;
somatic gene therapy for a recessive human genetic disorder	virus / liposome	;
plants that express a bacterial toxin that kills insects feeding on them	*Agrobacterium tumefaciens/* (Ti) plasmid / liposome	;
bacteria that produce a human protein for therapeutic use	BAC / (bacterio)phage / plasmid	;

IGNORE tumour forming bacterium

Question			Answer	Mark	Guid
5	(c)	**1**	somatic / adult, cell / nucleus ;	max 5	**1 ACCEPT** differentiated or body cell or example, e.g. skin cell, udder cell
		2	fused with / injected into ;		**2 ACCEPT** inserted / placed. If term use is "electrofused" gets mp 2 and mp 5
		3	empty / enucleate , egg cell ;		
		4	from another goat ;		**4 ACCEPT** named (A, B) or numbered goats
		5	*idea of* electric shock / electrostimulation ;		**5** "electrofused" gets mp 2 and mp 5
		6	this cell or embryo, grown on , in vitro / in tied oviduct ;		**6 ACCEPT** in petri dish / test tube culture
		7	(early) embryo / blastocyst , split ;		**7 ACCEPT** description of an embryo being split, even if produced by wrong method (IVF)
		8	*idea that* embryos replaced in , surrogate mothers / other females ;		**8 IGNORE** host mothers
		9	AVP ;		**9** e.g. further detail of any stage of process correct ref. to haploid / diploid , nuclei

Question			Answer	Mark	Guid
5	(d)			5 max	**IGNORE** disadvantages of breeding given in the first (advantages of cloning) section, i.e. **DO NOT CREDIT** reverse arguments
			advantages		
		A1	all offspring will inherit the, (silk) gene / foreign DNA ;		
		A2	all offspring female ;		
		A3	certain / all make , silk / milk / product ;		
		A4	faster / many obtained in a short time ;		
		A5	avoid mating risks ;		**A5 ACCEPT** idea of physical damage or disease transfer
			max 3 advantages		**IGNORE** advantages of breeding given in the second (disadvantages of cloning) section, i.e. **DO NOT CREDIT** reverse arguments
			disadvantages		**D1 ACCEPT** they are all genetically identical
		D1	no genetic variability (in population) / AW ;		
		D2	(so makes goats) more susceptible to, environmental factors / (infectious) disease ;		**D2 IGNORE** disease if stated to be genetic
		D3	cloned animals may, have shorter life spans / be less healthy ;		
		D4	*idea that* cloning success rate is very poor ;		
		D5	(more) expensive / needs (more) technology / (more) labour intensive ;		
			max 3 disadvantages		
			Total	**15**	