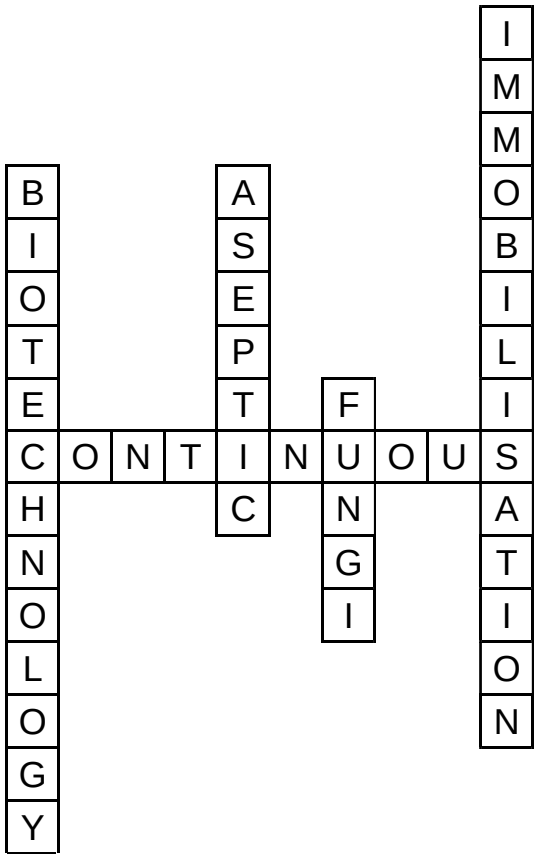
Question			answer	Mark	Guid
1	(a)				**FA for each microorganism** **IGNORE** prokaryotic / eukaryotic (as given in question)
			fungal long cells / hyphae OR multinucleate OR chitin cell wall **;**	1	
			bacterial free DNA / DNA not in a nucleus OR circular DNA (molecule) OR naked DNA / no histones OR peptidoglycan / murein, cell wall OR smaller / 70S / 18nm, ribosomes **;**	1	**ACCEPT** no nucleus / nuclear envelope **IGNORE** loop, plasmids, nucleoid
	(b)		disease-causing (organism) **;**	1	**IGNORE** harmful, infection

Question			Answer	Mark	Guid
1	(c)		*What is biotechnology?* **1** large-scale / industrial / commercial use (of living organisms / enzymes) **;**	7 max	
			2 to produce **,** food / named example **;**		**2** e.g. cheese / yogurt / beer / wine / cider / vinegar / soya sauce / mycoprotein / etc.
			3 detail of **,** microbe / enzyme **,** involved **;**		**3** e.g. *Lactobacillus* / yeast / *Fusarium* / etc. **IGNORE** wrong kingdom
			4 to produce **,** drugs / named example **;**		**4** e.g. antibiotic / penicillin / augmentin / insulin
			5 detail of **,** microbe / enzyme **,** involved **;**		**5** e.g. *Penicillium* **IGNORE** wrong kingdom
			6 to make **,** (useful) enzymes / biogas / calcium citrate / for bioremediation / for water treatment / for microbial mining **;**		**6** e.g. detergent enzymes, pectinase, sewage treatment, blue technology
			Advantages of microorganisms **7** fast, growth / reproduction / products **;**		
			8 microbes can be genetically engineered **;**		**8** **ACCEPT** in context of example mps **1 - 6**
			9 processes occur at low **,** temperatures / pressures **;**		
			10 low **,** temp / pressure **,** cheaper / safer **,** to maintain **;**		**10** **CREDIT** less energy used for low, temp /pressure
			11 products **,** pure / easy to separate **;**		**11** **ACCEPT** little downstream processing
			12 grow on unwanted, food / nutrients **;**		**12** **ACCEPT** named e.g. whey, starch waste.
			13 AVP **;** **QWC** – balanced account **;**	1	**13** e.g. no animal welfare issues Award QWC if 2 marks awarded from mps **1** – **6** **and** 2 marks awarded from mps **7** – **13**
			Total	**11**	

Question			Answer	Marks	Guidance
2				5	**CREDIT** asepsis for aseptic (3 down)
			Total	**5**	

Question			Expected Answer		Mark	Additional Guidance
3	(a)	(i)				**max 2 for description and max 2 for explanation** If bacteria mentioned, penalise once and then apply ecf. If incorrect units used, penalise the mark point and then apply ecf for subsequent mark points.
				description		
			1	lactose decreases and qualified **;**		***1*** eg ● single **figure quote** **either** at start (96 / 97 (a.u.)) **or** levelling-off point (45 - 60 h) **or** end (65 -70 h)
			2	ammonia decreases and qualified **;**		***2*** eg ● single **figure quote** **either** at start (34 (a.u.)) **or** levelling-off point (40 - 55 h)
			3	ammonia **,** plateaus / constant **,** at c. 2 (a.u.) (between 55 -140 h) **;** ***max 2***		***3***
				explanation		
			4	*idea that* lactose / ammonia **,** used **,** for growth / to make biomass **;**		***4***
			5	lactose / ammonia **,** used to make penicillin **;**		***5***
			6	lactose broken down to glucose (and galactose) **;**		***6***
			7	lactose / glucose **,** used for **,** respiration / energy **;**		***7*** **IGNORE** ammonia
			8	ammonia used to make named N-containing molecule **;** ***max 2***		***8*** eg ● amino acids / protein / nucleotides / nucleic acids / chitin / glycoprotein
					4 max	

Question			Expected Answer	Mark	Additional Guidance
3	(a)	(ii)	lactose **and** ammonia levels **,** stay high / oscillate **;** biomass **,** continues to rise / does not level off **;**	**2**	If bacteria mentioned, penalise once and then apply ecf. **IGNORE** incorrect ref to stationary phase **DO NOT CREDIT** 'remains constant' without the idea of more being added **ACCEPT** 'biomass **,** rises and falls / levels off**'** only if reference made to harvesting / removal
3	(a)	(iii)	*idea that* most penicillin produced after main growth phase **;** after 24 h / when nutrients declining **;** not needed for growth **;** (however evidence not entirely clear as) production begins during biomass log phase **;**	**2 max**	If bacteria mentioned, penalise once and then apply ecf. **IGNORE** incorrect ref to stationary phase
3	(b)	(i)	**1** to avoid unwanted microbe **,** entry / presence **;** **2** so no competition for nutrients **;** **3** so conditions remain unchanged **;** **4** so no decrease in yield **;** **5** so no contamination of **,** batch / product / penicillin **or** batch is unusable **;** **6** to prevent escape of **,** microbes / fungus / *Penicillium* / spores **;**	**3 max**	If bacteria mentioned, penalise once and then apply ecf. ***1*** **IGNORE** pathogens ***2*** ***3*** ***4*** ***5*** **DO NOT CREDIT** contamination unqualified ***6***

Question			Expected Answer	Mark	Additional Guidance
3	(b)	(ii)	temperature - as it affects enzymes **;** pH - as it affects enzymes **;** oxygen content – ref. respiration **;** AVP **;**	**3 max**	If bacteria mentioned, penalise once and then apply ecf. **DO NOT CREDIT** air eg ● salt concentration – affects osmosis / water potential / enzymes ● removal of waste gases (CO_2) – reduce pressure / prevents explosion of fermenter ● speed of stirrer – ensure even **,** mixing / temperature
			Total	**14**	

Question			Expected Answer	Mark	Additional Guidance
4	(a)	(i)	microbes **/** (living) organisms **/** cells **/** enzymes **;** (make) product **/** for human benefit / (carry out) conversion / reaction / industrial process **;**	**2**	**CREDIT** microorganisms / bacteria / prokaryotes / fungi **CREDIT** living things **CREDIT** cell components / parts of cells **CREDIT** example such as (named) food or medicine BUT **IGNORE** cheese (as stated in question) **IGNORE** process unqualified
	(a)	(ii)	microbes **/ AW ,** killed / removed / not present **;** enzymes <u>denatured</u> **;** (so no) competitors **/** unwanted reactions **/** (human) health risk **;**	**2 max**	**Mark the first two suggestions** **IGNORE** contamination / sterile **IGNORE** idea of preserving milk **AW** for microbes as in **(a)(i)** plus **ACCEPT** organisms **DO NOT CREDIT** microbes denatured **CREDIT** (no) competition **CREDIT** (no) food spoilage / change of flavour / loss of quality **CREDIT** (no) pathogens / harmful microbes / TB **"Kills harmful microbes"** or **"Kills pathogens"** scores 2 marks (mps 1 & 3)

Question			Expected Answer	Mark	Additional Guidance
4	(b)	(i)			**Award mp 1 plus 2 max from the other mark points**
		1	enzyme **;**		***1*** **ACCEPT** globular / tertiary / catalyst / catalytic (protein)
			plus any 2 of the following	**1**	
		2	(enzyme) not, changed / used up **; ora**		***2*** **ora** = can be used again / re-used **IGNORE** enzyme recycled
		3	*idea of* ESC (forms) / substrate and enzyme (bind) **;**		***3*** ESC = enzyme-substrate complex **ACCEPT** substrate entering active site
		4	products (and enzyme) released at end **;**		
				max 2	
	(b)	**(ii)**			**Mark the FIRST suggestion on each numbered line** **IGNORE** **'**cheaper' without qualification
		1	(enzyme can be removed to be) used again **;**		
		2	(enzyme can) to leave pure(r) product **; ora**		***2*** **ACCEPT** cheaper / easier, downstream processing
		3	(enzyme) more stable / more efficient / works better **;**		***3*** **CREDIT** less susceptible to, pH / temperature, change / extremes **"enzymes work at high temperatures"** = 0 **"enzymes work at higher temperatures"** = 1 (because comparative statement made)
				2	

Question			Expected Answer	Mark	Additional Guidance
4	(c)		***This is a QWC question***		
			Section I - Obtaining the gene		
		1	use restriction, enzyme / endonuclease **;**		
		2	to, cut out / get / isolate, (rennin) gene / DNA coding for rennin ***or*** to, fragment / digest, DNA **;**		***1*** **CREDIT** named example e.g. *Eco* R1, *Bam* H1, *Hin* dIII ***2*** **DO NOT CREDIT** 'cut gene' **IGNORE** 'break up DNA'
		3	gene probe **;**		
			OR		
		4	obtain rennin mRNA **;**		***NOTE***
		5	(use) reverse transcriptase **;**		***1-9*** **CREDIT** whichever of the three alternative "obtaining the gene" protocols yields most marks, **either award marking points 1- or 4-6 or 7-9**
		6	to make cDNA **;**		
			OR		
		7	sequence, rennin (protein) **;**		
		8	work out base code **;**		
		9	make this DNA sequence **;**		
		10	sticky ends **;**		***10*** can be awarded, once only, in Sections I or II
			Section II - Vector		
		11	cut (open), plasmid / phage **;**		***11*** **DO NOT CREDIT** 'cut out plasmid' **DO NOT CREDIT** 'ring of DNA' unless it is clear that plasmid is being referred to
		12	using same restriction enzyme **;**		***12*** **CREDIT** same named enzyme (re. mp1)
		13	annealing / base pairing of sticky ends **;**		***13*** **CREDIT** idea of sticky end bases hydrogen bonding
		14	join sugar-phosphate backbones **;**		***14*** **CREDIT** formation of phosphodiester bonds
		15	(using DNA) ligase **;**		
		16	recombinant, vector / plasmid / phage / DNA **;**		
			Section III - Introduction into host cell		
		17	mix with bacteria **;**		
		18	detail of conditions **;**		***18*** e.g. Ca^{2+} ions added / heatshock (freeze then inc to $40^{o}C$)
		19	transformation (plasmid) / transduction (phage) **;**		***19*** **CREDIT** transform / transformed / transduce / transduced **IGNORE** transgenic
				max 7	
			QWC – sequencing of steps – at least 1 mark point scored from each of the three sections, in the correct order ;	**1**	I. obtaining gene (mp **1 – 9**) followed by II. vector (mp **13 – 16**) followed by III. introduction to host cell (mp **17 – 19**)
			TOTAL	**17**	

Question			Answer	Marks	Guidance
5	(a)		**1** $\frac{\text{herbivore / primary consumer,energy}}{\text{producer energy}}$ x 100 **;**		**1 CREDIT** $\frac{\text{trophic level 2 energy}}{\text{trophic level 1 energy}}$ x 100 ; **CREDIT** sample figures. e.g. if producer energy 20 000 kJ m^{-2} and herbivore 2000 kJ m^{-2} calculation is 2000 / 20000 x 100 = 10% **CREDIT** $\frac{\text{Energy available after transfer}}{\text{Energy available before transfer}}$ x100 **IGNORE** ref to productivity
			Plus any 3 of the following: **2** (a sample of) producers collected **;** **3** (a sample of) herbivores /primary consumers collected; **4** (collected from) the same area **;** **5** **(**measure) biomass / dry mass (of individual or population) **;** **6** energy content calculated of producer **and** herbivore **;** **7** use of calorimeter / described;	**4 max**	**CREDIT named examples for 2 and 3** **ACCEPT '**organisms at each trophic level collected' for **1 mark** **5 ACCEPT** wet / fresh,mass **5 IGNORE** mass unqualified / pyramids of biomass **6 ACCEPT** expressed as J/KJ/MJ, per gram **IGNORE** calories per gram **7** e.g. burn sample, in oxygen / in measure temperature increase **ACCEPT** use of published tables for energy values of, fresh /wet, mass

Question			Answer	Marks	Guidance
5	(b)			6	**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**

Goal	Letter	
improving soil that is low in nutrients for the growing of wheat	F	;
preventing the spoilage of fruits after picking	E	;
reducing the impact of a fungal disease on yields from cucumber plants	A / B	;
producing strawberry plants that grow quicker and fruit earlier	A / B	;
making sugar syrup from waste starch	D	;
producing large amounts of a fungus for food	C	;

ACCEPT A / B

ACCEPT C

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>5</td><td>(c)</td><td></td><td>
<table>
<tr><th>Description</th><th>Name</th></tr>
<tr><td>Sparrows initially fly away from fruit bushes on which shiny CDs are hung, particularly when the CDs move in the wind.</td><td>escape reflex ;</td></tr>
<tr><td>After a few days the sparrows start visiting the fruit bushes again, and do not fly away even when the CDs move.</td><td>habituation ;</td></tr>
<tr><td>Carrot flies move towards chemicals released by carrot plants.</td><td>(positive chemo-) taxis ;</td></tr>
<tr><td>Raccoons learn to remove lids from containers of grain in a barn.</td><td>operant conditioning / trial and error (learning) ;</td></tr>
<tr><td>A line of young chicks follow their mother into a cornfield.</td><td>imprinting ;</td></tr>
</table>
</td><td>5</td><td>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

IGNORE innate / instinctive / learnt (as stated in Q)

DO NOT CREDIT negative chemotaxis
ACCEPT taxes

CREDIT insight (learning) / latent (learning)/ intelligent learning / observational learning</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>15</td><td></td></tr>
</table>