

Q1.

3 (a) (i)

bacterial strain	A	B	
diameter (d) / mm	24	16 ;	
area / mm ²	452 - 453	201 – 201.2 ;	A ecf
ratio of area A : area B	2.25 : 1	A 9:4	A ecf

[3]

- (ii)
1. penicillin kills more of strain A than strain B or C / AW ;
 2. ref. different active or binding sites ;
 3. A produces less penicillinase than B or C ;
 4. C is resistant (to penicillin) ;
 5. C has mutation ;
 6. penicillin cannot bind to enzymes ;
 7. penicillin inactivated by C / C produces much penicillinase ;
 8. AVP ; e.g. B is evolving into a more resistant strain / variation in carriers across membrane
- [4 max]

- (iii)
1. antibiotic, is selective agent / provides selective pressure ;
 2. resistant survive / susceptible die ;
 3. ref. reproduction ;
 4. resistants pass on, mutation / allele ; R gene
 5. ref. vertical transmission ;
 6. increases frequency of allele in population ;
 7. may pass advantageous mutation to other species / ref. plasmid transfer ;
 8. ref. horizontal transmission ;
- [4 max]

accept reference to strains A, B and C in correct context for points 2, 3 and 4

- (b)
1. competitive inhibitors (of transpeptidase) ;
 2. binds to enzyme ;
 3. blocks active site ;
 4. crosslinks in peptidoglycan wall cannot form ;
 5. weakens cell wall ;
 6. lysis / cell bursts ;
 7. ref. high internal pressure of bacterial cell ;
- [4 max]

[Total: 15]

Q2.

-
- 5 (a) 1 bacterium obtains energy ;
2 for synthesis of materials ;
3 for, growth / division ;
4 does not need to use carbon compounds for energy ; A named carbon compound
[2 max]
- (b) 1 takes up large area ;
2 unsightly ;
3 requires, lot of water / continuous water supply ;
4 contamination of water / pollution due to acid ;
5 Cu / Fe, toxic to plants ; [2 max]
- (c) *bioleaching (accept ora for mining)*
1 low level technology / no sophisticated machinery / requires less maintenance ;
2 low energy consumption / less fossil fuels used ;
3 few safety hazards / safer ; R no hazards
4 organism easy to, obtain / culture ;
5 self replicating ;
6 waste less hazardous ;
7 disposal of waste, costs less / is easier ;
8 ref. low grade ores / scrap iron ;
9 less workers needed ;
10 ref. use in situ ; [4 max]

[Total:8]

Q3.

- 5 (a) *marking points refer to batch culture*
- 1 (penicillin) is a secondary metabolite / product ; **R** *Penicillium*
 - 2 more penicillin is produced (per unit time) ; **A** higher yield *comparative statement*
 - 3 in the later stages of growth (of the culture) / after main growth phase is over ;
 - 4 (penicillin produced when, fungus / *Penicillium*,) is short of nutrients ; **R** no nutrients left
- alternative points for 2 and 3 for continuous culture (ora)*
- 2a less penicillin is produced (per unit time) ; *comparative statement*
- 3a continuous culture remains in, exponential / active growth, phase ; [3 max]
- (b) *description*
- when pH is controlled (blue unbroken line)*
- 1 penicillin is produced throughout the time period ;
- when pH not controlled (blue dotted line)*
- 2 penicillin production increases to a maximum and then decreases ;
 - 3 2 penicillin figs plus 2 time figs (to support 1 or 2) ; *ignore pH figs*
- explanation*
- 4 (pH affects) enzymes (involved in penicillin production) ;
- when pH is controlled*
- 5 optimum pH for enzymes is at approx pH 7 ;
- when pH not controlled*
- 6 pH, high / above 7, decreases / stops, penicillin production ;
 - 7 (pH, high / above 7), causes change in active site of enzymes / AW ; [4 max]
- (c) 1 penicillin affects (bacterial) cell wall production ; **A** affects cross-linkages
- 2 inhibits, glycoprotein peptidases / enzymes involved with constructing (bacterial) cell wall ;
 - 3 viruses do not have cell walls ; [2 max]

[Total: 9]

Q4.

- 2 (a) 1 hamster injected with, antigen/CD40 ;
2 B cells/plasma cells, with ability to make antibody taken ;
3 from spleen ;
4 (B cells/plasma cells) fused with, tumour/cancer/myeloma, cell ;
5 use of, fusogen/PEG ;
6 (hybrid) cells cultured/AW ; **R** use of fermenter
7 check cells for mAb production ;
8 (antibody making) cells mass produced/AW ; **A** use of fermenter [4 max]

(b) (i) *accept mouse survival for heart survival*

- 1 in **A**, 100% hearts survive 10 days **or** no heart survives 20 days ;
- 2 in **D**, 100% hearts survive, 80 days/to end of investigation ;
- 3 in **B**, 100% hearts survive 30 days **or** 10% hearts survive, 80 days/to end of investigation ;
- 4 in **C**, 100% hearts survive 30 days **or** 75% hearts survive, 80 days/to end of investigation ;

penalise once for no mention of percentage in mps 2, 3 and 4

[4]

(ii) 1 in **D**, both pathways/CD28 and CD40, blocked ;

2 so T-cells cannot be cloned/no immune response ;

3 in **B**, CD40 pathway is not blocked/only CD28 is blocked ;

4 so T cells can still be cloned/immune response triggered ;

[2 max]

(c) 1 carry blood to, cardiac/heart, muscle/tissue/cells ;

2 supply oxygen ;

3 supply, nutrient/named nutrient ;

4 for, energy release/respiration ; **R** produce energy

[3 max]

(d) *two of the following:*

1 diagnosis of, disease/named disease ; e.g. gonorrhoea/HIV

2 treatment of disease ; e.g. directing drugs to cancerous cells **A** autoimmune disease but **not** tissue or blood typing

3 pregnancy testing/drug testing ;

4 (passive) vaccine production ;

[2 max]

[Total: 15]

Q5.

- 3 (a) 1 penicillin inhibits enzyme ; *ignore name of enzyme*
2 peptidoglycan chains cannot link up/stops cross-links forming ;
3 cell wall becomes weaker/AW ;
4 turgor of cell not resisted (by cell wall)/AW ;
5 cell/wall, bursts ; [3 max]
- (b) (i) **B** has, an outer membrane/channel proteins ;
B has thinner (peptidoglycan) wall ; *accept ora for A* [2]
- (ii) 1 penicillin V can reach the, wall/(cell surface) membrane, of **A** ; **ora**
2 outer membrane of **B** stops penicillin V getting through ; **ora**
3 penicillin V cannot get through pores of outer membrane of **B** ; [2 max]
- (iii) can penetrate outer membrane ;
through pores/directly through as non-polar ; [2]
- (c) *batch culture*
1 set up and allowed to proceed ;
2 nutrients not added or products removed, (during fermentation) ;
3 air allowed in/waste gas allowed out ;
4 at end of each process, product harvested/fermenter cleaned out ; *max 2*
- continuous culture*
5 nutrients added (all the time) ;
6 products removed (all the time) ;
7 no down time/AW ; *max 2* [3 max]
- (d) 1 (*Penicillium*/fungus), does not make penicillin all the time/penicillin is made in the later stages of growth ;
2 when beginning to run out of nutrients ;
3 (penicillin) is a secondary metabolite ;
4 continuous culture has no yield of penicillin ;
5 continuous culture, never reaches stationary phase of growth/always exponential growth ; [3 max]

[Total: 15]

Q6.

- 2 (a) (i) any one from ;
hot springs
sulphur springs
geysers
geothermals
marine vent
volcanic area
hot desert [1]
- (ii) 1. each bacterium grows at a different temperature (range) ;
2. (the heap) heats up ;
3. idea of when temperature kills one species of bacterium others are still active
or
as temperature increases process can continue ;
4. increased oxidation of heap ;
5. more productive / enables increased yield of gold ; [3 max]
- (b) (i) 1. *A. ferrooxidans* increases, oxidation of the ore / production of Fe^{3+} ;
2. little difference in effect 0–5 days ;
3. greatest effect after 15 days ;
4. comparative figs for with and without *A. ferrooxidans* on a single day ; [3 max]
- (ii) 1. cheaper (than other methods) ;
2. does not require energy input ;
3. does not require other chemicals to be purchased ;
4. does not require specialist equipment ;
5. can be done *in situ* ;
6. less labour needed ;
7. bacteria are self-replicating / AW ;
8. more environmentally friendly than other methods / no harmful emissions / AW ;
9. useful for extraction from, low grade ores / waste ; [3 max]
- (c) *must have at least one D mark to score 4 marks*
D1 both strains give similar rate with and without arsenic ions ;
D2 both strains are arsenic-resistant ;
D3 strain 2, more active / higher oxidation rate, (than strain 1) ;
E4 arsenic acts as a selective, agent / pressure ;
E5 mutation / AW, produces resistant bacteria ;
E6 resistant bacteria survive / **ora** ;
E7 resistant allele passed on ;
E8 frequency of allele increases (in population) ; [4 max]

[Total: 14]

Q7.

- 2 (a) 1. (solutions of) alginate and enzyme mixed ;
2. droplets (of mixture) into calcium chloride (solution) ;
3. to produce beads ; [2 max]
- (b) 1. idea of easier purification of product ;
2. enzyme, can be reused / is not lost / has longer shelf life ;
3. allows continuous culture ;
4. cheaper ; 2 max
- (c) *description*
1. immobilised papain more active / papain in solution less active, at higher temperatures ;
2. idea of difference above 30°C ;
3. comparative figs ; e.g. values of activity for **both** at any **one** temperature above 30°C
explanation
4. (inert support) protects enzyme ; **A** beads
5. tertiary structure / 3D structure / active site, (of the enzyme) is stabilised ;
6. less denaturation ;
7. H bonds, vibrate less / less easily broken ;
accept ora for mp4–mp7 [4 max]
- [Total: 8]

Q8.

- 5 (a) 1. higher yields / more crop survives ;
2. less need to use pesticides / crop pest-resistant ;
3. (reduced pesticide use) may benefit other organisms in the same environment ;
4. less risk of harm to humans, from spray drift / from pesticide residues on food ;
ignore refs to cost [2 max]
- (b) (eating Bt maize) reduces growth rate ;
0.6 compared to 0.7 / difference of 0.1 ; [2]
- (c) 1. experiments done in laboratory and not in the ecosystem / AW ;
2. predicts what could happen if Bt toxin conc. increases in the future ;
3. may not (normally) feed on pollen ; [2 max]
- (d) 1. such results likely to have a negative effect on public perception (of GM crops) / AW ;
2. might reduce work for researchers in this area ;
3. might reduce income of companies (producing GM crops) ;
4. increased use of pesticides ; [1 max]

Q9.

- 2 (a) (i) 1. ref. antigen presenting cells ;
2. (antigen) A recognised as, non-self / AW ;
3. by B lymphocytes;
4. with appropriate, receptor / antibody / immunoglobulin ;
5. ref. clonal selection ;
6. (B lymphocytes) clonal expansion / mitosis / cell division ;
7. T-helper cells to stimulate B-cell (response) ;
8. release cytokine;
9. (B lymphocytes) mature into plasma cells ;
10. (plasma cells) secrete (anti-A) antibody ; [4 max]
- (ii) plasma cell fused with, myeloma / cancerous / malignant, cell ; [1]
- (iii) 1. B cells / plasma cells, will not grow in culture / cannot divide (AW) / short-lived ;
2. cancerous / malignant / myeloma, cells divide, indefinitely / continuously
or
hybridoma divides (AW) indefinitely ;
3. AVP ; e.g. to obtain, genetic material / genes / genomes, from both cells [2 max]
- (iv) use of marker described (attached to, antigen A / specific mAB against mouse antibody); [1]
- (b) (i) 1. all infliximab treatments reduce percentage with increased joint damage ;
2. (general trend) high dosage / more infliximab, percentage with increased joint damage lower
or
low dosage / less infliximab, percentage with increased joint damage higher ;
3. both increasing dosage & decreasing time intervals have an effect;
4. at high dosage increasing time interval shows, percentage with increased joint damage is similar / AW ;
5. at low dosage increasing time interval shows, the percentage with increased joint damage is less / AW;
6. 30.5% with no infliximab to 0.5 – 1.0% with most infliximab / 30% decrease ;
7. other comparative data ; [3 max]

(ii) because small numbers involved / AW ;

[1]

(c) *N.B. diagnosis not treatment*

1. quick diagnosis;
2. than having to culture pathogen ;
3. (quicker diagnosis) so quicker treatment ;
4. less labour intensive (than culturing) ;
5. not all pathogens can be cultured ;
6. microscopic identification difficult ;
7. viruses difficult to identify ;
8. AVP ; e.g. ref. specificity / ref. non-pathogenic diseases

[3 max]

[Total: 15]

Q10.

- 2 (a) 1. *idea of* wait for / time needed for, immune response to occur ;
2. ref. B lymphocytes mature to, plasma cells / effector B cells ;
3. plasma / effector B, cells secrete antibodies ;
4. plasma / effector B, cells extracted from (mouse) spleen ;
5. fused with, myeloma / cancerous / malignant, cells ;
6. (hybridoma cells) cultured ; **A** before or after mp7
7. identify cells secreting antibody (specific / against *T. pallidum*); *ignore* 'containing'
8. AVP ; e.g. use of fusogen [4 max]
- (b) 1. (solution of) H9-1 / antibody added ; *ignore injecting*
2. given time for binding (then washed off) ;
3. examined with microscope ;
4. using, UV light ; **A** laser
5. fluorescent / yellow, treponemes are *T. pallidum* ; [3 max]
- (c) *dark-field microscopy*
1. not enough treponemes (*T. pallidum*) present ;
2. (*idea of*) not noticed among other treponemes ;
blood test
3. not enough antibodies present to measure (in plasma) ; *ignore absent*
4. in host cells but not in blood / takes time to reach blood stream from point of entry ;
5. ref. time for immune response to occur / immunocompromised people ; [2 max]

- (d) (i) 1. H9-1, more accurate than other tests / correct in all cases ;
2. small number of false results from other tests ;
3. blood test least accurate ;
4. comparative figures ; (dark-field microscopy v. blood test)
e.g. of acceptable figures:-
(dark-field microscopy) 1 false negative and 2 false positives / ~ 5% / 3 errors out of 61 / 3.33% false negatives
(blood test) 3 false negatives and 2 false positives / ~ 8% / 5 errors out of 61 / 10% false negatives
5. comment re: small numbers ; [3 max]
- (ii) 1. had infection before / antibodies already present ;
2. (have antibodies to) other treponemes that share an antigen with *T. pallidum* ; [1 max]
- (e) *N.B. treatment not diagnosis*
1. *idea of* (monoclonal) recognise, specific antigen / cancer cell ;
2. (monoclonal) carries, drug / radioactive molecule / coloured molecule ;
ignore magic bullet alone
3. how this leads to treatment ; e.g. *cytotoxicity / effect radiation / effect laser*
4. as passive vaccine ;
5. (monoclonal) injected directly into, blood / body, to attack a particular pathogen ; [2 max]

[Total: 15]

Q11.

- 3 (a) 1. nutrients added **and** product removed at a steady rate/AW;
2. (so) volume kept constant;
3. organism kept at, exponential/log, phase of growth; [max 2]
- (b) 1. (branched fungus tangles together in clumps so) too heavy for bubbles to, lift/stir
OR ref. to blocking;
2. difficult to, harvest/get desired texture;
3. mutant may be, harmful when eaten/toxic/allergenic;
4. mutant may produce, distasteful/coloured, substance;
5. mutant may be less productive;
6. mutant may have high concentration of RNA (which is difficult to lower);
7. approval for sale only applies to original strain; [max 4]
- (c) 864 kg; [1]
- [Total: 7]**

Q12.

- 3 (a) 1. nutrients added **and** product removed at a steady rate / AW;
2. (so) volume / named condition, kept, constant / at an optimum;
3. organism kept at, exponential / log, phase of growth; [2 max]
- (b) (i) 1. at, low / 7.0, (carbon concentration) higher temperature causes increases in, growth / dry mass;
2. at, high / 14.0, (carbon concentration) higher temperature causes little or no change in, growth / dry mass;
3. comparative figures plus units; [3]
- (ii) *carbon or nitrogen source*
1. to produce, amino acids / proteins / enzymes;
2. to produce, nucleic acids / nucleotides / ATP / purines / pyrimidines / named N-base;
3. chitin / building block, for cell wall;
carbon only
4. used in respiration;
5. to produce, carbohydrates / sugar / polysaccharide / glycogen / lipids; [3 max]
- [Total: 8]**

Q13.

- 4 (a) 1 (mouse) injected with antigen ; **A** protein / red cells
2 spleen / plasma / B, cell ;
3 with ability to make antibody ; *linked to 2*
4 fused with, tumour / myeloma / cancerous, cell ;
5 cells cultured ;
6 cells checked for antibody production ;
7 cells cloned ; [4 max]

- (b) (i) 1. Herceptin / X-ray, induces (slightly) more cell death than control ;
A more effective
2. X-rays induce more cell death than Herceptin ; **A** more effective
3. comparative figures supporting 1 or 2 ; e.g. 0.6 or 0.75 v 0.5
4. Herceptin and X-rays induce much more cell death (than either treatment alone) ; **A** highest / most / greatest, effect
5. comparative figures supporting 4 ; e.g. 2.0 v 0.6 or 0.75 [3 max]
- (ii) $\frac{2.0 - 0.6}{0.6} \times 100 \%$
- = 233 % ;; *award 2 marks for correct answer ignore decimal places*
- allow 1 mark for valid working if answer incorrect* [2]
- (c) (i) 1. increase in dose of X-ray causes, decrease in % cells surviving / more cell death ;
2. increase in X-ray dose plus Herceptin causes greater, decrease in % cells surviving / cell death ;
3. difference greatest above 2 (J kg⁻¹) ; **R** ref to time or rate [3]
- (ii) identifies cancer cells ;
immune response triggered ;
- enters cancer cell ;
kills it ;
- Herceptin enhances effect of X-ray ; [2 max]

[Total: 14]

Q14.

3	(a)	(i)	so that, the bacteria were not killed / enzymes not denatured ;	[1]
		(ii)	1. bacteria put into (solution of) sodium alginate ; 2. place mixture in syringe ; 3. add drops of mixture to calcium chloride solution ; 4. calcium ions replace sodium ions (to form beads) ; 5. bacteria trapped in beads ;	[3 max]
	(b)	(i)	<i>note comparison between blue line and black line ignore references to red line - agar</i> 1. both increase up to, 18 / 24, hours ; 2. both similar, initially / up to 18 hours ; 3. biggest difference at 24 hours / rate of increase for immobilised cells greater than free cells between 18 and 24 hours ; 4. after 24 hours immobilised cells rate decreases while free cells rate continues to increase <u>or</u> after 39 hours free cells rate is greater than immobilised cells rate ; 5. free cells final concentration is still lower than highest value attained by immobilised cells ; 6. use of comparative figures ;	[4 max]
		(ii)	1. (could be) less surface area (to volume ratio) in cubes than beads ; 2. (could be) a greater diffusion distance to centre of cubes than beads ; 3. agar may be less permeable (to substrate) than alginate ; 4. something in agar may inhibit bacterial enzymes ; 5. some protease <u>adsorbed</u> by agar ;	[2 max]

	(c)	(i)	82.14 / 82.1 / 82 (%) ; ; <i>allow one mark for suitable working if incorrect answer</i>	[2]
		(ii)	1. can use alginate (beads) many times ; 2. (reduces cost of), materials / energy / labour ; 3. fewer bacterial cultures needed / less time spent immobilising bacteria ; 4. more protease produced (per hour) (using alginate) ; 5. can run fermentation for longer time ; 6. less time wasted between fermentations ; <i>answers must imply comparison</i>	[3 max]
				[Total:15]

Q15.

3	(a)	(i)	<u>condensation</u> ;	[1]
		(ii)	1. <u>autolysins</u> ; 2. make holes in cell walls ; 3. in, growing / developing, bacteria ; 4. (antibiotic), inhibits / acts on, (another) enzyme ; 5. so peptidoglycan chains cannot link up / stops cross-links forming ; 6. cell wall becomes weaker / AW ; 7. turgor of cell not resisted (by cell wall) / AW ; 8. cell bursts ;	[4 max]
		(iii)	(glycoprotein) peptidase ; R other peptidase	[1]
	(b)		viruses have no cell wall ;	[1]
	(c)		<i>assume gram+ unless otherwise stated</i> 1 (gram+) penicillin can reach, cell wall / peptidoglycan, directly / AW / (gram-) ora ; 2 (gram-) outer membrane provides protection (from penicillin) / (gram+) ora ; 3 (gram+) more % peptidoglycan in wall (so greater effect from penicillin) / (gram-) ora ;	[2 max]

	(d)	<p><i>accept antibiotic for penicillin and bacteria for S. pneumoniae throughout</i></p> <ol style="list-style-type: none"> 1 increase in resistance (throughout time period) ; 2 paired figs + units ; 3 overuse / misuse, of penicillin ; 4 some <i>S. pneumoniae</i> survive ; 5 mutation (in <i>S. pneumoniae</i>) ; 6 resistance, <u>gene</u> / <u>allele</u> ; 7 resistance passed to other bacteria ; e.g. plasmid transfer 8 resistant strain, multiplies ; <i>idea of many produced</i> 9 beta – lactamase produced ; 10 breaks down penicillin ; <p><i>point 7 accept vertical or horizontal transfer</i> <i>point 8 accept vertical transfer only</i></p>	
			[5 max]
			[Total: 14]

Q16.

- 2 (a) (i) 1 penicillin ~~inhibits~~ enzyme / peptidase ;
2 blocks / alters shape of, active site ;
3 peptidoglycan chains cannot link up / stops cross-links forming ;
4 cell wall weaker / AW ;
5 turgor of cell not resisted (by cell wall) / AW ;
6 cell / wall / bacterium, bursts ; [3 max]
- (ii) *any two from*
1 viruses do not have cell wall ;
2 viruses do not have cytoplasm ;
3 viruses do not have peptidoglycan ;
4 viruses do not have peptidase ; [2 max]
- (b) *without antibiotic*
1 numbers of both wild-type and mutant strains, increase / hardly changes ;
with antibiotic
2 numbers of both wild-type and mutant strains decrease ;
3 mutant strains decrease more than wild-type ; **A faster**
this subsumes marking point 2
4 after 24h, wild-type plateaus and mutant strain continues to decrease ;
5 ref. comparative figures at any one time ; *ignore units for bacteria*
blue with blue
red with red
red with blue – with antibiotic [4 max]

- (c) (i) 1 changes in, base / nucleotide, sequence ; **A** named change
e.g. substitution
- 2 alters, triplet code / codon ;
- 3 enzyme has different, primary structure / amino acid sequence ;
- 4 enzyme has different, 3D structure / tertiary structure / active site ; [2 max]
- (ii) *red and blue with antibiotic*
- 1 wild-type bacteria can produce glucans
or mutant bacteria produce less glucans ;
- 2 glucans bind with antibiotic ;
- 3 wild-type more resistant to antibiotic **or** mutant bacteria less resistant to
antibiotic ; [2 max]
- (d) 1 antibiotic, is selective agent / provides selective pressure ;
- 2 resistant bacteria, survive / reproduce ;
- 3 pass allele for resistance to offspring ;
- 4 frequency of allele in population increases ; [3 max]

[Total: 16]

Q17.

- 3 (a) (i) hybridoma ; [1]
- (ii) 1 identical (antibodies) **or** produced by cloning ;
2 variable regions / antigen binding sites, all identical
or (antibodies) are specific to one antigen ; [2]
- (iii) *Mark text first*
1 (four) polypeptides ; *plural*
2 two heavy **and** two light chains ; **A** long and short
3 ref. disulphide, bridges / bonds ;
4 ref. variable regions / binding sites ; [3 max]
- (b) (i) 1 HAT cannot be metabolised / AW ;
2 HAT inhibits mutant myeloma cells / AW ; [2]
- (ii) 1 mouse spleen cells can metabolise HAT / AW ;
2 because they have suitable enzyme ; [2]
- (iii) 1 so that only fused cells survive **or** unfused myeloma cells die ;
2 identifies, cells to be cloned / fused cells ; [2]
- (c) 1 can be done at home / easy to use / non-invasive ;
2 cheap ;
3 result produced quickly ;
4 result likely to be accurate ;
5 can be done early in pregnancy ;
6 safe to use ; [4 max]

[Total: 16]

Q18.

- 2 (a) 1. allele for lactase deficiency is recessive ; **A** allele for lactose intolerance
2. parents, heterozygous / carriers ;
3. child homozygous recessive ; [2 max]
- (b) (i) 1. at low temperatures activity of, immobilised lactase is lower (than free lactase) / free lactase is higher (than immobilised lactase) ;
2. ref 42–43 °C as changeover point ;
3. maximum activity of immobilised lactase is lower (than free lactase) / ora ;
4. idea of optimum temperature of immobilised lactase 40–45 °C and optimum for free lactase is 35 °C ;
5. comparative figures at any one temperature ; (units required for temperature only) [3 max]
- (ii) assume immobilised accept ora
1. harder for substrate to reach enzyme ;
2. harder for product to pass out of bead ;
3. accumulation of product leads to product inhibition ;
4. idea of enzyme less able to move leading to fewer ES complexes / AW ; [2 max]
- (c) 1. can re-use enzyme / enzyme not lost / AW ;
2. ref. cost effective ;
3. idea of, easier to purify product / less contamination of product ;
4. greater stability at higher temperatures / thermostable ;
5. idea of, copes with any pH / pH stable ; [3 max]

[Total: 10]

Q19.

- 2 (a) 1. 6 penicillin inhibits enzyme / peptidase ;
2. blocks / alters shape of, active site ;
3. peptidoglycan chains cannot link up / stops cross-links forming ;
4. (so) cell wall weak(er) ;
5. turgor of cell not resisted (by cell wall) /
idea of inability to withstand increased internal pressure ;
6. cell / wall / bacterium, bursts ; *ignore 'dies' as in question* [4 max]
- (b) 1. mRNA produced by transcription ;
2. *idea of* triplet code ;
3. translated (at ribosome) ;
4. correct ref. to function of tRNA ; e.g. anticodon / carries amino acid
5. formation of polypeptide ;
6. AVP ; e.g. ref. tertiary structure / 3D shape / ref. bonds [3 max]
- (c) (i) *mutant strain 1*
1. very low resistance **or** affected by low concentration of antibiotic ; **A** less resistant
2. gene (for efflux pump) not properly, expressed / switched on ;
3. (so) few pumps (produced) **or** pumps out less antibiotic ;
A pumps not working well [2 max]
- mutant strain 2*
4. more / x4, resistant **or** tolerates high concentration of antibiotic ;
5. gene (for efflux pump fully), expressed / switched on ;
6. (so) many pumps available **or** pumps out more antibiotic ; [2 max]
- (ii) 1. natural selection ;
2. antibiotic provides selection pressure ;
3. mutant **2** has selective advantage ;
4. in presence of >64 **and** $<256 \mu\text{g cm}^{-3}$ antibiotic ;
5. **R** dies / mutant strain **2** survives ;
6. mutant **2**, reproduces / increases in number ;
7. (so) passes, resistance / mutation, (to offspring) ; *ignore allele / gene* [4 max]

[Total: 15]

Q20.

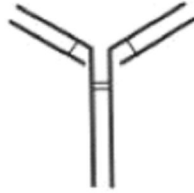
- 3 (a) 1 globular ;
2 ref. tertiary structure / 3D shape ;
3 active site (because enzyme) ;
4 outer amino acids with hydrophobic R groups (because in membrane) / AW ; [2 max]
- (b) 1 (penicillin) binds, rarely / briefly, with PBP2a ;
ignore doesn't bind well
2 (so) most PBP2a molecules not blocked ;
3 (so) cell wall / cross links, can still be made (in presence of penicillin) ;
4 penicillin is competitive inhibitor (of PBP) ;
5 (so) reduces PBP enzyme activity ; [3 max]
- (c) 1 viruses have no (peptidoglycan) wall ;
2 viruses have no, transpeptidase / glycoprotein peptidase ;
3 viruses, have no cell structure / are not cells ;
4 viruses have no metabolism ; [2 max]
- [Total: 7]

Q21.

- 2 (a) *prevents*
1 growth of new blood vessels (to tumour) ;
2 supply of (more), oxygen / nutrient ; **A** named nutrient
3 more routes for metastasis / AW ; [max 2]
- (b) (i) VEGF ; [1]
(ii) cell formed by fusion of a plasma cell **and** a cancer cell ;
A B-lymphocyte, B cell, splenocyte **and** myeloma cell [1]
- (c) 1 does not act as foreign antigen / AW ;
2 (so) does not cause, immune response / rejection ;
3 avoids, allergic reactions / side effects / anaphylactic shock ;
4 allows more than one treatment ;
5 remains in body for longer (so more effective) ; [max 3]

(d) drawing IgG
ignore labels

four polypeptide chains shown ; *in correct positions*
(disulfide) bridges shown to link chains ;



[2]

[Total: 9]

Q22.

- 5 (a) (i) 1 performed in an open fermenter/nutrients added at a steady rate throughout ;
2 products harvested throughout ;
3 pH/temp/oxygen concentration, controlled throughout ;
4 *ref. to input = output/constant volume ;* [max 2]
- (ii) 1 organisms maintained in exponential phase ;
2 faster rate of enzyme production ;
3 no build-up of toxins ;
4 no down time /AW ;
5 small vessels can be used ;
6 cost effective ; [max 3]
- (b) (i) 1 percentage breakdown (of azo-dye) increased, between 7 and 10 days/
after 10 days ;
after 7 days
2 percentage breakdown (of azo-dye) increased with increasing
concentration of azo-dye, up to 150 mg dm^{-3} /except for 200 mg dm^{-3} ;
3 two breakdown percentages at two dye concentrations to support mp2 ;
after 10 days
4 percentage breakdown (of azo-dye) decreased with increasing
concentration of azo-dye ;
5 two breakdown percentages at two dye concentrations to support mp4 ; [max 4]

- (ii) 1 time is not taken for enzymes to leave white-rot fungal cells ; **ora**
2 lower concentration of enzymes from white-rot cells ; **ora**
3 AVP ; e.g. possible inhibitory effect of azo-dye on white-rot cells/ ESCs formed more quickly [max 2]

- (c) 1 enzyme can be, re-used/ recovered after use ;
2 enzyme does not contaminate water / no purification needed ;
3 *idea of* enzymes being thermostable ;
4 *idea that* enzymes able to withstand pH changes ;
5 *ref. to* increased shelf-life of enzyme ; [max 3]

[Total: 14]

Q23.

- 1 (a)** use of living organisms/biological agents/animals/plants/cells/
microorganisms;
to, produce useful products/produce foods/produce medicines/
produce chemicals/process other materials/treat waste;
in fermenter/culture vessel/AW; **max 2**
- (b)** ref. availability of information;
ref. public knowledge/understanding/awareness (of information);
ref. complexity of issues;
ref. actual/potential benefits importance;
ref. actual/potential risks;
ref. perceptions of benefit/risk;
ref. political/commercial pressures;
ref. misinformation/AW; **max 4**
- (c) (i)** initial levels, normal higher than GM/ora;
normal has a more rapid rise from 0-4 days/ora;
normal reaches much higher level at 4/8 days/ora;
normal stays same level from (approx.) 4-8 days/while GM rises
slightly;
normal drops again after 7/8 days/GM continues to rise after 7/8 days; **max 3**
- (ii)** idea of – start later;
idea of – happen slower; **2**
- (iii)** not ripe/green when picked;
long shelf life/AW;
will not over-ripen;
do not ripen too quickly;
do not become squashy/firmer;
AVP; **max 2**
- (iv)** ref. moral principles/personal choice/values of society/AW;
ref. to actual/potential/perceived advantages/named advantage;
ref. to actual/potential/perceived risks/hazards/named risk/hazard;
AVP. **max 2**
- [15]**

Q24.

2. (a) (i) no moving parts;
continuous circulation;
maintained using difference in specific gravity;
of rising aerated culture and air-depleted culture;
heat exchange removes heat;
produced from respiration; 3 max
- (ii) C source / glucose ;
N source / ammonia;
growth factor / choline ;
minerals / ammonium sulphate / zinc sulphate / copper sulphate / iron sulphate; 3 max
- (b) coloured;
flavoured;
fibres pressed to form pieces / ref texture;
reduction of RNA; 2 max
- Total 8**

Section_B

1.

- 9 (a) 1. DNA not surrounded by nuclear membrane / no nucleus;
2. (prokaryote) DNA is circular;
3. DNA not associated with histones; **A** naked DNA
4. plasmids (may) be present;
5. no (double) membrane-bound organelles; **A** no, mitochondria / chloroplasts
6. no, ER / Golgi; **A** ribosomes not attached to membranes
7. ribosomes, 70S / 18 nm / smaller (than eukaryotic cells);
8. cell wall made of, peptidoglycan / murein / amino sugars / AW;
9. (usually) unicellular;
10. 0.5 to 5.0 μm diameter; **A** any value between 0.5 and 5.0 as long as μm is used
11. AVP; (may) have, flagella / pili / capsule / slime layer [8 max

- (b) 12. ores (may) contain metal sulfides;
13. example; e.g. iron / copper / zinc / cobalt / lead
14. insoluble in water so difficult to extract;
15. bacteria oxidise metal sulfide;
16. to soluble sulfate;
17. bioleaching;
18. example of bacteria; e.g. *A.ferrooxidans*
19. bacteria need to survive in acidic conditions;
20. mixture of bacteria required (in bioheap);
21. (in order to) survive a wide range of temperatures / range of bacteria with different temperature optima;
22. advantage;
- 23 e.g. low grade ores / spoil heaps, can be exploited
can get metal from industrial waste
does not produce sulfur dioxide
can be done in situ
low energy demand
less (heavy) machinery
not labour intensive
relatively cheaper (than other mining methods)
24. AVP; e.g. ref. gold / uranium

[7 max]

[Total: 15]

2.

- 10 (a)
1. regulatory gene codes for repressor protein ;
 2. (repressor protein) binds to operator region ;
 3. (repressor protein) blocks promoter region ;
 4. lactose binds to repressor protein which changes shape ;
 5. (repressor protein with bound lactose) breaks away from operator region ;
 6. promoter region now unblocked, so RNA polymerase binds to promoter region ;
 7. structural genes transcribed ;
 8. and translated ;
 9. enzymes formed ;
 10. ref. lactose permease and uptake of lactose from medium ;
 11. ref. β -galactosidase and breakdown of lactose ;
 12. into, glucose / galactose ;
- [max 9]

- (b)
1. DELLA proteins inhibit germination ;
 2. seed absorbs water ;
 3. stimulates production of gibberellin ;
 4. by embryo ;
 5. gibberellin causes breakdown of DELLA proteins ;
 6. leads to transcription of mRNA coding for amylase ;
 7. in aleurone layer ;
 8. (amylase) hydrolyses starch to maltose ;
 9. ref. maltose converted to glucose ;
 10. glucose respired by embryo during germination ;
- [max 6]

[Total: 15]

3.

- 10 (a) bacteria walls made of peptidoglycans ;
- bacteria secrete autolysins ;
- make holes in cell wall/ **AW** ;
- to allow wall to stretch during growth/ **AW** ;
- (glycoprotein) peptidases form cross-links (between peptidoglycans) ;
- (penicillin) inhibits (glycoprotein) peptidases ;
- cross-links (between peptidoglycans) do not form ;
- cell wall weakened ;
- bacteria take in water by osmosis ;
- increased turgor pressure causes cell to burst ; **AW**
- AVP ; e.g. competitive inhibition
- [max 8]

(b) ref. bioleaching ;

Acidithiobacillus/A. ferrooxidans ; **A** *Thiobacillus/T. ferrooxidans*

low grade ores/(mine) waste ;

two metals ; e.g. copper, zinc, cobalt, uranium, lead, nickel, gold, silver
Iron

insoluble ore turned into soluble products ;

ore piled up ;

acidic conditions created /pH low(ered)/pH 1.5 – 3 ;

different bacteria at different temperatures ;

chemoautotrophic ; **A** description

oxidation (reactions) ;

sulfide/ S^{2-} to sulfate/ SO_4^{2-} ; (direct oxidation of ore)

Fe^{2+} / ferrous \rightarrow Fe^{3+} / ferric ;

Fe^{3+} oxidise other ores ;

product, drains/ leaches/is washed, into pool ;

metal displaced by adding scrap iron ;

[max 7]

[Total:15]

4.

- 10 (a) use *Penicillium* (in batch fermenter) ;
(main) nutrients added at start ;
penicillin only produced, after growth phase/ when running out of nutrients ;
(penicillin) is a secondary metabolite ;
fermentation is stopped ;
penicillin is harvested ;
fermenter is cleaned out/ ref. sterility ;
new culture of *Penicillium* is put in and started again ;
ref. fed batch culture ;
carbohydrate / named nutrient, added regularly ;
keeps fermentation going longer / produces more penicillin ;
detail of fermenter ;; e.g. paddle to mix nutrients / sterilising steam inlet
/ set at pH 6.5 / aeration / kept at 27 °C

[max 8]

- (b) *batch*
easy to set up culture ;
can continue with minimal attention / AW ;
environmental conditions easy to control ;
fermenter can be used for different process afterwards ;
only waste one batch if contaminated ;
less chance of blockage in fermenter ;
continuous
no / less, down time / AW ;
small vessels can be used ;
productivity high ;
cost effective ;
downstream processing easier ;
good for using immobilised enzymes ;

[max 7]

[Total:15]

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