<table>
<thead>
<tr>
<th>Question No.</th>
<th>Part</th>
<th>Sub-part</th>
<th>Marking Guidance</th>
<th>Mark</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a</td>
<td>i</td>
<td>ATP attaches to binding sites (on CFTR protein); ATP is broken down to ADP and inorganic phosphate (Pi); (conformational) change in protein shape; chloride channel opens/chloride ions pass through channel.</td>
<td>3 max</td>
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<td></td>
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<td>ii</td>
<td>Release energy.</td>
<td>1</td>
<td>Reject ‘produces energy’.</td>
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<td></td>
<td>b</td>
<td>i</td>
<td>Bacteria get stuck in mucus, which cannot be coughed away from lungs.</td>
<td>1</td>
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<td></td>
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<td>ii</td>
<td>Pancreatic juice containing amylase cannot pass down pancreatic duct (to small intestine).</td>
<td>1</td>
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<td></td>
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<td>iii</td>
<td>Sperm cannot pass down the seminiferous tubules.</td>
<td>1</td>
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<td>7</td>
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<tr>
<td>2</td>
<td>a</td>
<td>i</td>
<td>Higher partial pressures of carbon dioxide increase the dissociation of oxyhaemoglobin.</td>
<td>1</td>
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<td></td>
<td></td>
<td>ii</td>
<td>High partial pressure of carbon dioxide from respiration cause oxyhaemoglobin to give up oxygen more readily/reduces haemoglobin’s affinity for oxygen.</td>
<td>1</td>
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<td></td>
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<td>iii</td>
<td>Carbon dioxide form hydrogen carbonate ions in solution; hydrogen carbonate binds to site on crocodile haemoglobin; haemoglobin shape does not change as much as human haemoglobin; oxygen not released until very low partial pressure of oxygen.</td>
<td>2 max</td>
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<td></td>
<td>b</td>
<td>i</td>
<td>Tertiary because folded into globular shape. Quaternary because more than one polypeptide chain/four polypeptide chains.</td>
<td>2</td>
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<td></td>
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<td>ii</td>
<td>Carbon dioxide dissolves to form hydrogen carbonate ions; hydrogen carbonate ions bind to the binding site on haemoglobin; haemoglobin changes shape decreasing its affinity for oxygen/so oxygen is released more readily.</td>
<td>2 max</td>
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<td>8</td>
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<tr>
<td>3</td>
<td>a</td>
<td>i</td>
<td>Length of DNA; which codes for a particular polypeptide/protein.</td>
<td>2</td>
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<td></td>
<td>ii</td>
<td>Cut gene for Bt production from bacterium using restriction enzyme; insert gene for Bt production into plasmid (from Agrobacterium tumefaciens); using DNA ligase; insert modified plasmid back into (A. tumefaciens) bacterium; infect potato plant cell with (A. tumefaciens) bacteria.</td>
<td>4 max</td>
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|   | b | Beetles without resistance gene are killed by Bt/beetles with resistance gene are not killed by Bt; when spray is used some leaves will be missing but in Bt producing potato plants all leaves have Bt; this increases the selection pressure/only those beetles with resistance gene survive when potato leaves are eaten. | 2 |

| 4 | a | i | 2.1 ppm Value when percentage mortality is 50%. | 1 |
|   | ii | More than 50% of mosquito population survive insecticide treatment; some mosquitoes with a gene which gives resistance to the insecticide will survive; these mosquitoes will reproduce and pass on the resistance gene; so more mosquitoes will become resistant to the insecticide. | 2 |

|   | b | Treatment with solution containing no insecticide; to show insecticide was cause of death. | 2 |
|   | c | Soluble so can get into waterways/drinking water; chemically stable so does not break down in environment/body; can accumulate in the food chain/bioaccumulation. | 3 |
|   | d | i | Inhibitor attaches to site on enzyme other than active site/allosteric site; changes shape of enzyme/active site so substrate no longer fits. | 2 |
|   | ii | Acetylcholine is a neurotransmitter; fits in receptor sites on postsynaptic membrane and causes sodium ion channels to open; action potential generated in postsynaptic neurone; if acetylcholine not broken down it will continue to enter receptors. | 3 max |

<p>|   | e | i | No danger of pollution from insecticide; specific to the pest/beneficial insects not harmed; once established does not need to be reapplied; no resistance in pest. | 2 max |</p>
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<tr>
<td></td>
<td>ii</td>
<td>Slow to establish; pest never fully eliminated.</td>
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<tr>
<td>5</td>
<td>a</td>
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<tr>
<td></td>
<td>i</td>
<td>Starch</td>
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<tr>
<td></td>
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<td>monomer is α-glucose</td>
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<tr>
<td></td>
<td></td>
<td>forms coiled structure</td>
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<td></td>
<td>ii</td>
<td>[Diagram of glucose monomers]</td>
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<td>iii</td>
<td>The shape of cellobiose is different to shape of maltose; shape of active site on amylase; only complementary to maltose/can only make enzyme substrate complex with maltose.</td>
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<td>1 max</td>
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<td></td>
<td>b</td>
<td>i</td>
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<tr>
<td></td>
<td>ii</td>
<td>Rabbits have a larger surface area to volume ratio; so lose more heat from their surface.</td>
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<td>iii</td>
<td>Both animals eat grass which has a lot of cellulose; cellulose cannot be digested by the animals and most will be lost as faeces; of the food which is digested and absorbed some will be used in respiration; heat generated by respiration.</td>
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<td>2 max</td>
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<tr>
<td></td>
<td>c</td>
<td>i</td>
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<tr>
<td></td>
<td>ii</td>
<td>Radiation; body temperature is higher than environment.</td>
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<td></td>
<td>iii</td>
<td>Rabbits eat grass and so compete with cattle for food; rabbits grow (and reproduce) rapidly.</td>
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<td>iv</td>
<td>Less body heat lost by evaporation; so less water lost; higher core temperature.</td>
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<td>3 max</td>
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<td><strong>16</strong> Looking for comparison.</td>
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</table>

- **3 max** for correct H and OH groups. Should have two molecules of β-glucose. Second molecule may be inverted. One mark for correct H and OH on carbon 1. One mark for correct H and OH on carbon 4. Assuming rest of molecule is correctly drawn.

- **2 max** for correct H and OH groups. Should have one molecule of β-glucose and one molecule of α-glucose. First molecule may be inverted. One mark for correct H and OH on carbon 1. One mark for correct H and OH on carbon 4. Assuming rest of molecule is correctly drawn.
| 6 | a | **Similarities:**
|   |   | electrons pass down electron transfer chain;
|   |   | (electrons) reduce carriers/passage involves redox reactions;
|   |   | electron transfer chain/role of chain associated with a membrane;
|   |   | energy released/carriers at decreasing energy levels;
|   |   | ATP generated from ADP and phosphate/PI/phosphorylation of ATP;
|   |   | chemiosmosis/description of.
|   | b | **Differences:**
|   |   | respiration has substrate level phosphorylation/description of ATP
|   |   | production in glycolysis/Krebs cycle;
|   |   | electron transfer chain on thylakoids in photosynthesis, cristae/inner
|   |   | membrane of mitochondrion in respiration;
|   |   | coenzymes – NADP in photosynthesis, NAD (and FAD) in respiration.

| 7 | a | i To cut the DNA.  
|   |   | ii To separate the (fragments of) DNA.  
|   | b | Complementary base sequence/complementary DNA;
|   |   | binds to both (haplotypes);
|   |   | label would show up in both.
|   | c | i Bottleneck;
|   |   | present population descended from small number/fewer than 100/1970 population;
|   |   | with small number few haplotypes/little genetic variation/little genetic
|   |   | diversity/few base sequences.

**General points**
Releases energy in small/manageable amounts directly to process.
Phosphorylates/adds phosphate.
Makes (phosphorylated substances) more reactive/lowers activation energy.
Reformed/made again.

**Description of uses of ATP in cells**
Any two from:
- active transport;
- cell division;
- muscle contraction;
- nerve impulse transmission;
- rhodopsin in eye;
- other valid uses of ATP in cells e.g. synthesis of molecules.

Do not accept phosphorus or P on its own.
Must relate to regeneration.
Must be a description not just naming the process using ATP.
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<tbody>
<tr>
<td>ii</td>
<td>All descended from Italian wolves/founder effect;</td>
<td>1</td>
<td>Reject same wolves. Must convey idea of descendants. Accept there would be more if larger samples.</td>
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<td>d</td>
<td>i</td>
<td>Y chromosome inherited/comes from male parents/only found in males.</td>
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<td></td>
<td>ii</td>
<td>Mitochondria in egg/female gamete/no mitochondria come from sperm/male gamete.</td>
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<tr>
<td>e</td>
<td>i</td>
<td>Allows comparison; different (sized) areas covered.</td>
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<td></td>
<td>ii</td>
<td>Wolves do not eat all of prey animal/do not eat (large) bones/skin; inedible parts make up different proportions/wolf eats different proportions.</td>
<td>2</td>
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<td>f</td>
<td>Limited by food/prey; as prey increases so do wolf numbers/positive correlation; large range so other factors involved.</td>
<td>2 max</td>
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<td>8</td>
<td>a</td>
<td>Any three from: polysaccharide; unbranched/straight chain; β-glucose; (1,4) glycosidic bonds (between glucose molecules); chains cross-linked by hydrogen bonds.</td>
<td>3 max</td>
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<td>b</td>
<td>Xylem/sclerenchyma.</td>
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<td>c</td>
<td>Reference to decomposition/decay/putrefaction (by microorganisms); extracellular digestion/reference to digestive enzymes; reference to respiration; releases carbon dioxide for photosynthesis; methane released in anaerobic (conditions); (methane) available as fuel.</td>
<td>3 max</td>
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<td>d</td>
<td>i</td>
<td>Any one from: reference to increased income; in order to export fuel; reference to more jobs; reduce imports of fuels; reference to biofuels being renewable/sustainable; fossil fuels finite; reduce use of/as alternative to fossil fuels; reference to no loss of farmland.</td>
<td>1 max</td>
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ii  Reference to (combustion of) biofuels releases carbon dioxide recently removed from atmosphere (or other correct alternatives to this statement); (therefore) there is no (net) increase in carbon dioxide (in atmosphere); carbon dioxide is a greenhouse gas; that absorbs/traps infra-red/heat/long-wave (radiation reflected from Earth’s surface); reference to prevents infra-red/heat/long-wave escaping into space; reference to (therefore) mean temperature of Earth’s surface increases; idea that carbon in peat (land) was trapped a long time ago; idea of peatland clearance releases carbon dioxide; idea that there is a (net) gain of carbon dioxide (in the atmosphere); idea that removal of plants (during clearance) reduces photosynthesis; reference to carbon dioxide released from (clearance) machinery.

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<tr>
<td>9</td>
<td>a</td>
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</table>
| i | Protein in thin filament = actin/G actin, 14%  
   | Protein in thick filament = myosin, 10%  
| ii | Calcium ions bind to troponin; troponin changes shape/moves; this displaces troponin (away from myosin).  
| iii | Wall of right atrium.  
| b | i The higher troponin T, the longer the hospital stay.  
| ii | Reliability of prediction decreases as troponin T concentration increases; because range increases; least reliable for 6.0+ as range is largest; one range stated, e.g. ‘for 6.0+ it is 7–11 days’; idea that 6.0+ is too wide a category for concentration of troponin T; idea that the higher the troponin T, the greater the damage to the heart.  

QWC – Spelling of technical terms must be correct and the answer must be organised in a logical sequence.
| 10 | a | 1 Pathogen causes disease/not all parasites cause disease.  
2 (Influenza) virus causes a disease/influenza is a disease.  
3 Parasite gains nutrition/energy from host;  
**OR**  
(influenza virus) does not gain nutrients/energy from host.  
4 Virus takes over (host cell) DNA/genetic material. | 3 max | Accept damage to health/illness, for ‘disease’.  
1 Ignore ‘parasites do not cause disease’.  
2 Do not credit ‘virus is a disease’/‘influenza causes disease’;  
accept ‘(swine) flu is a disease’;  
note: the influenza virus is a pathogen because it causes disease = two marks (marking points 1 and 2).  
3 Accept alternative wording for ‘gains nutrition from’, e.g. ‘feeds on’;  
ignore ‘lives off host’/‘benefits from host’;  
accept idea of ‘host’ in context of suitable example. |
|---|---|---|---|---|
| b | i | (Response) to an antigen;  
volves lymphocytes/production of antibodies. | 2 | |
| ii | 1 Antibodies are proteins.  
2 DNA unable to leave nucleus.  
3 mRNA, copies/is a copy of, gene/part of DNA.  
4 RNA passes out of nucleus/through nuclear pore/into cytoplasm.  
5 To/at ribosome/rough ER.  
6 Ribosome made of (r)RNA.  
7 (RNA needed for) protein synthesis/formation of polypeptides.  
8 Amino acids brought by tRNA. | 5 max | QWC – two roles of RNA.  
Award +1 if marking points 3 or 4 plus if points 6 or 7 or 8 are seen.  
1 Must be a clear statement; accept proteins make antibodies; accept antibodies are polypeptides.  
3 Accept mRNA involved in transcription of DNA; ignore transcription unqualified;  
accept ‘a section of DNA acts as a template for mRNA’ if the idea of mRNA copying part of DNA is clearly present.  
5 Accept in context of mRNA or tRNA.  
6 Ignore ‘ribosomal RNA’ unqualified.  
7 Ignore translation unqualified. |
<p>| iii | If no other marks have been awarded, credit one mark max for: antibodies bind to antigens (on pathogen). <em>Otherwise, mark as follows:</em> neutralisation; antibodies, cover binding sites on pathogen/bind to toxins; prevent, binding/entry, to (host) cell; agglutination; clump/bind together, (many) pathogens; (clump) too large to enter host cell/increase likelihood of being consumed by (named) phagocyte. <em>The following could be credited:</em> opsonisation; activation of complement; increase likelihood of being consumed by (named) phagocyte; lysins; destroy (or alternative wording) pathogens. | 4 max |
|     | Accept ‘prevent host cell becoming infected’. Ignore ‘white blood cell’; do not accept lymphocyte; accept neutrophils/macrophages/mothers. | |</p>
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<tbody>
<tr>
<td>c</td>
<td>i</td>
<td>1</td>
<td>Patients with HIV+/AIDS/transplant/chemotherapy.  2 Weak immune system/cannot produce (many) antibodies.  3 Pregnant women.  4 Fetus (or embryo) has undeveloped immune system/antibodies can cross placenta.  5 Health workers/or people living or working close to an outbreak.  6 Likely to be at (increased) risk (of disease).  7 Those with (named) chronic diseases, e.g. asthma/diabetic/heart disease/tuberculosis/autoimmune disease.  8 Idea of inability to withstand further disease/already being in poor health.</td>
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</table>
|   |   | 4 | Explanation marks can be awarded without awarding corresponding group mark unless clearly incorrect in context. Mark the first two groups of people mentioned, max two marks for each group.  1 Accept ‘patients with weak immune system’ but do not also credit for point 2; accept ‘cancer’ but ignore ‘homeless people’.
|   |   |   | 3 Ignore babies (as close to stem).
|   |   |   | 4 Accept ‘baby’ as alternative wording for ‘embryo’; ignore weak immune system; accept underdeveloped immune system; ignore foetus gets antibodies from mother.
|   |   |   | 5 Accept suitable named professional, e.g. nurse/doctor; accept ‘people who have been in contact with disease’ unqualified; ignore references to overcrowding; ignore ‘working with animals’ unless it is clear that the animals are infected.
|   |   |   | 6 Accept reference to health workers being important in control of outbreak.
|   |   |   | 7 Ignore ‘lung disease’; ignore ‘homeless people’.
<p>|   |   |   | 8 Accept idea of weakened immune system for this marking point if not credited for points 1 or 2. |
| ii |   | Idea of: days lost at work/effect on economy; costing more to deal with the ill people (than the cost of vaccination); response to public opinion; health service unable to cope; eliminating a disease. |
|   |   | 1 max | Do not accept reference to antibiotics treating viruses. |</p>
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</table>
| **iii** | **Idea of:**
|   | being too busy/can’t be bothered/feel it is unnecessary;
|   | lack of trust in government;
|   | media scare stories;
|   | concerned about side-effects;
|   | cost implication to individuals;
|   | allergic to vaccine;
|   | altruistic reason/other people more deserving;
|   | fear of needles;
|   | religious/cultural/ethical reasons;  |
|   | **1** Ignore ‘risk’ unqualified throughout.
|   | **Accept ‘conflicting research’**.
|   | Ignore ‘not natural’.  |
| **11** | **a** Push = legume; Pull = grass.  |
|   | **1** Both needed for mark.  |
| **b** | Set up tape measures on two sides of the plot/make grid of plot;
|   | use random number table/calculator/generator;
|   | to generate coordinates.  |
|   | **3** Allow ‘number each plant’. With this approach ‘to generate coordinates’ cannot be awarded. Allow ‘select from a hat’ idea.  |
| **c** | To prevent competition between the maize and the grass;
|   | for light/nutrients/water.
|   | **OR**
|   | Idea of limits movement of pest (between grass and maize);
|   | only eating/damaging grass.  |
|   | **2 max**  |
| **d** | Nitrogen-fixing bacteria convert nitrogen (in the air) into ammonium compounds (in the soil);
|   | these ammonium compounds are converted into nitrates/nitrification occurs;
|   | maize uses nitrates (in soil) for amino acid/protein/ATP/nucleotide production;  |
|   | **2 max** Accept ‘ammonia’ for ‘ammonium compounds’.
|   | Must be in the context of maize; ignore ionic formulae unless only these are given.  |
| **e** | **1** Reduced % damage to maize plants/increased maize grain yield.
|   | **2** Calculation to justify point 1.
|   | **3** Standard deviation shows no overlap but need statistics to show significance of this difference.
|   | **4** More profit/net income/greater income than additional cost (with push-pull).
<p>|   | <strong>5</strong> $322 extra/408% more/$401 v $79 profit.  |
|   | <strong>3</strong> Accept ‘$350 extra income compared with $28 extra spend’; this marking point gains credit for both points 4 and 5.  |</p>
<table>
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<tr>
<th>12</th>
<th>a</th>
<th>i</th>
<th>Cytoplasm (of cell).</th>
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<tr>
<td></td>
<td></td>
<td>ii</td>
<td></td>
<td>3 max + 1</td>
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<tr>
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<td>1 Phosphorylation of glucose.</td>
<td>QWC + 1 if technical terms used appropriately and spelled correctly. Marks can be awarded for a diagram.</td>
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<td>2 So forming hexose 1,6-bisphosphate.</td>
<td>1 Reject substrate level phosphorylation.</td>
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<td>3 (Then) splitting into/formation of two triose phosphate/s (TP).</td>
<td>2 Ignore glucose 6-phosphate/fructose 6-phosphate; allow fructose 1,6-bisphosphate; accept hexose biphosphate; reject hexose diphosphate.</td>
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<td>4 (For formation of pyruvate) dehydrogenation/oxidation/formation of reduced NAD.</td>
<td>3 Ignore hydrolysis; Do not credit if ATP or NAD or reduced NAD involved in conversion of hexose biphosphate to TP.</td>
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<td>5 Pyruvate produced (from TP/3C intermediate).</td>
<td>4 Accept formation of NADH/ NADH(^{+})/reduced NAD; Do not credit NADPH(^{+})/NADPH(^{+})/reduced NADP; Z, reject NADP.</td>
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<td>6 Total production four ATP/net production of two ATP.</td>
<td>6 Needs to be a clear statement. Use of three terms (including from a flow chart) from: phosphorylated (or derived term) glucose; hexose 1,6-bisphosphate, triose phosphate; dehydrogenation OR oxidation (or derived terms); pyruvate.</td>
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<th>b</th>
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<td>W = ethanal;</td>
<td>4 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.</td>
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<td>X = carbon dioxide;</td>
<td>W, correct spelling only, reject ethanol;</td>
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<td></td>
<td>Y = reduced NAD;</td>
<td>X, reject CO(_2)/CO;</td>
</tr>
<tr>
<td></td>
<td>Z = NAD(^{+}).</td>
<td>Y, accept NADH(_2)/NADH(^{+})/NADH(^{+})/reduced NAD; reject NADPH(_2)/NADPH(^{+})/NADPH(^{+})/reduced NADP;</td>
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<td>Z, reject NADP.</td>
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<tr>
<td>c</td>
<td>i</td>
<td>Treatment A produced less alcohol (than the control) at all times. Treatment V produced less alcohol (than the control) at 30, 45 and 60 hours/from 30 hours/after 15 hours; <strong>OR</strong> treatment V had the same alcohol as the control at 15 hours. Treatment C produced less alcohol (than the control) at 30 and 45 hours; <strong>OR</strong> treatment C produced more alcohol (than the control) at 15 and 60 hours.</td>
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<td>ii</td>
<td>At 60 hours: V has fewer yeast cells (which would ferment the sugar); <strong>OR</strong> C has more yeast cells. Only a small number of bacteria in V are fermenting the sugar /producing alcohol; <strong>OR</strong> the type/species of bacteria in V are not fermenting the sugar/producing alcohol; <strong>OR</strong> most/all/type of bacteria in C are fermenting the sugar/producing alcohol.</td>
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<td>iii</td>
<td>Treatment A/(weak) alkaline (solution); (A has the least contamination as) it has very few bacteria and little alcohol.</td>
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<td>13</td>
<td>a</td>
<td>i</td>
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<td></td>
<td>ii</td>
<td>Immune system less effective/more likely to have other infections/been in hospital.</td>
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<td></td>
<td>b</td>
<td>Attaches to active site (of enzyme); (methicillin) is a competitive inhibitor/prevents monomers/substrate attaching (to enzyme).</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>i</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>ii</th>
<th>Increase up to 2006 and then decrease; use of figures from graph, e.g. increase from less than 500 in 1993 to over 2000 in 2006, dropped to just over 500 by 2012.</th>
<th>2</th>
<th>One mark for general trend. Two marks for more detailed description using figures from the graph.</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td>1 (Antibiotic) resistant gene/allele. 2 Vertical (gene) transmission. 3 Resistant bacteria (survive and) reproduce/population of resistant bacteria increases. 4 Increase in frequency of (resistant) allele/gene (in future generations). 5 Horizontal (gene) transmission. 6 Plasmid. 7 Conjugation/pilus (tube). 8 (Horizontal transmission/conjugation) can occur between bacteria of different species.</td>
<td>6 max</td>
<td>Penalise reference to mitosis once when linked to either marking point 2 or 3. Penalise reference to immunity once when linked to either marking point 1, 3 or 4. Accept binary fission for reproduction in marking point 3. Accept ‘transfer’ for transmission.</td>
<td></td>
</tr>
<tr>
<td>e</td>
<td>Isolation of patients to prevent spread/more hand washing (by staff or visitors/more thorough cleaning of hospitals.</td>
<td>1</td>
<td>Accept any sensible suggestion.</td>
<td></td>
</tr>
</tbody>
</table>