

| Question number | Answer | Mark |
|-----------------|--|------|
| 1(a) | An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (1 mark): <ul style="list-style-type: none"> • Mendel crossed homozygous tall and homozygous short pea plants and produced all tall offspring (1) • therefore all the offspring had a heterozygous genotype with one tall and one short allele showing that the tall allele is dominant (1) | (2) |

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|-----------------|---|------|
| 1(b)(i) | An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (1 mark): <ul style="list-style-type: none"> • asexual reproduction is a rapid reproduction technique allowing the production of more plants • as there is no requirement for cross pollination/higher crop yield/increased profit | (2) |

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|-----------------|---|------|
| 1(b)(ii) | An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (1 mark): <ul style="list-style-type: none"> • introduces variation into the population • which allows for natural selection of fitter plants/increased chance of the population surviving | (2) |

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|-----------------|--------|------|
| 1(c)(i) | C | (1) |

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|-----------------|---|------|
| 1(c)(ii) | An explanation that combines identification via a judgement (1 mark) to reach a conclusion via justification/reasoning (1 mark): <ul style="list-style-type: none"> • genotype is $X^D X^d$/she must have one dominant and one recessive allele (1) • because her daughter must have received the recessive allele and her son has inherited a dominant allele (1) | (2) |

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|-----------------|--------|------|
| 2(a)(i) | B | (1) |

| Question number | Answer | Mark |
|-----------------|--------------|------|
| 2(a)(ii) | TACGTACATGGC | (1) |

| Question number | Answer | Additional guidance | Mark |
|-----------------|--|---|------|
| 2(a)(iii) | <ul style="list-style-type: none"> 3.33×10^{-10} equals 0.33 nm (1) $0.33 \times 250 = 82.5$ (nm) (1) | <p>maximum one mark if no conversion to nm</p> <p>award full marks for correct numerical answer without working</p> | (2) |

| Question number | Answer | Additional guidance | Mark |
|-----------------|--|--|------|
| 2(b)(i) | <ul style="list-style-type: none"> heterozygous | accept alleles showing heterozygous genotype | (1) |

| Question number | Answer | Mark | | | | | | | | | |
|-----------------|--|------|---|---|---|----|----|---|----|----|-----|
| 2(b)(ii) | <ul style="list-style-type: none"> correct Punnett square (1) <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td></td> <td>A</td> <td>a</td> </tr> <tr> <td>A</td> <td>AA</td> <td>Aa</td> </tr> <tr> <td>a</td> <td>Aa</td> <td>aa</td> </tr> </table> <ul style="list-style-type: none"> 75% normal fur pigmentation (1) | | A | a | A | AA | Aa | a | Aa | aa | (2) |
| | A | a | | | | | | | | | |
| A | AA | Aa | | | | | | | | | |
| a | Aa | aa | | | | | | | | | |

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|-----------------|---|------|
| 2(c) | <p>An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (1 mark):</p> <ul style="list-style-type: none"> both parents must be heterozygous for the recessive allele (1) so the offspring must inherit the recessive allele from each parent (1) | (2) |

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|-----------------|---------------------------------|--------------------|------|
| 3(a)(i) | D ☒ homozygous recessive | | (1) |

| Question Number | Answer | Acceptable answers | Mark |
|-----------------|---|---|------|
| 3(a)(ii) | <p>A description to include three of the following points:</p> <p>tired / lethargic (1)</p> <p>short of breath / reduced oxygen carrying capacity / problems exercising (1)</p> <p>swelling of hands and feet (1)</p> <p>painful / weak joints (1)</p> <p>blocked blood vessels / blood clots(1)</p> | <p>Accept weak/fatigued/</p> <p>Accept difficulty breathing</p> <p>Accept reference to pain or painful episodes/sickle cell crisis</p> <p>Ignore references to the shape of the red blood cell</p> <p>Ignore references to mucus</p> | (3) |

| Question Number | Answer | Acceptable answers | Mark | | | | | | | | | |
|-----------------|---|--------------------|------|---|---|----|----|---|----|----|---|-----|
| 3(b)(i) | <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td></td> <td>D</td> <td>d</td> </tr> <tr> <td>D</td> <td>DD</td> <td>Dd</td> </tr> <tr> <td>D</td> <td>DD</td> <td>Dd</td> </tr> </table> <p>correct gametes (1)</p> <p>correct offspring genotypes (1)</p> | | D | d | D | DD | Dd | D | DD | Dd | <p>Allow ECF for incorrect gametes</p> | (2) |
| | D | d | | | | | | | | | | |
| D | DD | Dd | | | | | | | | | | |
| D | DD | Dd | | | | | | | | | | |

| Question Number | Answer | Acceptable answers | Mark |
|-----------------|-----------------------|---|------|
| 3(b)(ii) | 50(%) (1) 0(%) (1) | Answers must be in this order Possible ecf from the candidates Punnett square Clip together with 1bi | (2) |

Total for Question 3 = 8 marks

| Question Number | Answer | Acceptable answers | Mark |
|-----------------|--------|--------------------|------------|
| 4(a)(i) | 75% | | (1) |

| Question Number | Answer | Acceptable answers | Mark |
|-----------------|--|--|------------|
| 4(a)(ii) | <p>An explanation linking two of the following:</p> <ul style="list-style-type: none"> • Punnett square would predict 50% normal 50% carrier (1) • actual offspring are not 50% carrier (1) • the probability is applied to each child not the overall offspring (1) | <p>accept ratios or probabilities instead of percentages</p> <p>actual offspring are 75%</p> <p>accept references to random assortment</p> | (2) |

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|------------------|---|--------------------|------|---|---|---|----|---|----|----|---|------------|
| 4(a)(iii) | <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td></td> <td>b</td> <td>b</td> </tr> <tr> <td>B</td> <td>b</td> <td>Bb</td> </tr> <tr> <td>b</td> <td>bb</td> <td>bb</td> </tr> </table> <p>Probability = 50%</p> <p>Ratio 2/4, 2:2, can be given for probability</p> <p>1 mark for correct gametes</p> <p>1 mark for completed Punnett square with correct probability</p> | | b | b | B | b | Bb | b | bb | bb | <p>Accept reverse order for gametes</p> <p>Accept letters other than B/b (but alleles must be the same letter)</p> <p>50% mark can only be given if 50% of the offspring are homozygous recessive</p> | (2) |
| | b | b | | | | | | | | | | |
| B | b | Bb | | | | | | | | | | |
| b | bb | bb | | | | | | | | | | |

| Question Number | Answer | Acceptable answers | Mark |
|-----------------|---|--------------------|------------|
| 4(a)(iv) | A <input checked="" type="checkbox"/> homozygous dominant (BB) | | (1) |

| Question Number | Indicative Content | Mark | | | | | | | | | |
|-----------------|---|---|---|---|---|----|----|---|----|----|------------|
| QWC | <p>*4(b) A explanation to include some of the following points:</p> <p>Pedigree analysis would show the likelihood of their offspring inheriting the disorder</p> <p>Pedigree analysis should also be carried out on the partners of the third generation.</p> <ul style="list-style-type: none"> • X is not a carrier • X is homozygous dominant • and does not have sickle cell disease • The parents of X are heterozygous / his sister has sickle cell • so will not pass on the allele for the disease to offspring • if his partner is a carrier • there will be a 50% chance of the child being a carrier • Y and Z are carriers of the sickle cell allele • Y and Z are heterozygous • The mother of Y has sickle cell / Y will inherit the sickle cell allele • The parents of Z do not have sickle cell / mother is a carrier/heterozygous • They have a 50% chance of passing the sickle cell allele onto their potential offspring • If their partners were also carriers • There would be a 25% chance that the offspring will have the sickle cell disease • There would be a 50% chance that the offspring would also carry the allele for sickle cell disease <p>Example Punnett square:</p> <table border="1" data-bbox="628 1316 1129 1428" style="margin-left: auto; margin-right: auto;"> <tr> <td></td> <td>B</td> <td>b</td> </tr> <tr> <td>B</td> <td>BB</td> <td>Bb</td> </tr> <tr> <td>b</td> <td>Bb</td> <td>bb</td> </tr> </table> | | B | b | B | BB | Bb | b | Bb | bb | (6) |
| | B | b | | | | | | | | | |
| B | BB | Bb | | | | | | | | | |
| b | Bb | bb | | | | | | | | | |
| Level | 0 | No rewardable content | | | | | | | | | |
| 1 | 1 - 2 | <ul style="list-style-type: none"> • a limited explanation the genetic profile of X,Y and Z or an explanation of the use of pedigree analysis • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy | | | | | | | | | |
| 2 | 3 - 4 | <ul style="list-style-type: none"> • A simple explanation of the genetic profile of X, Y and Z and an explanation of the use of pedigree analysis • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy | | | | | | | | | |
| 3 | 5 - 6 | <ul style="list-style-type: none"> • a detailed explanation of the genetic profile of X, Y and Z and explanation of the use of pedigree analysis plus either an explanation of one genotype or a prediction of one of the offspring outcomes • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors | | | | | | | | | |

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|-----------------|--------|--------------------|------------|
| 5a (i) | D - ff | | (1) |

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|-----------------|--|--------------------|------------|
| 5a (ii) | <p>An explanation linking two of the following:</p> <ul style="list-style-type: none"> • mucus blocks (pancreatic) duct /small intestine wall / digestive system(1) • preventing enzymes/named enzyme being released (into small intestine) (1) • less digestion of food (1) • less absorption (1) | | (2) |

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|-----------------|--|---------------------|------------|
| 5b (i) | an individual who has one recessive allele and one dominant allele (1) | 2 different alleles | (1) |

| Question Number | Answer | Acceptable answers | Mark |
|-----------------|--|--|------------|
| 5b (ii) | <p>An explanation to include two of the following:</p> <ul style="list-style-type: none"> • Rebecca is homozygous dominant(for CF)(1) • Rebecca has (inherited) one dominant allele from each parent(1) • cystic fibrosis involves the inheritance of two recessive alleles (1) | Rebecca has (inherited) 2 dominant alleles | (2) |

| Question Number | Indicative Content | Mark | | | | | | | | | |
|----------------------------|--|------|---|---|---|----|----|---|----|----|------------|
| QWC *5(c) | <p>An explanation including the following points:</p> <ul style="list-style-type: none"> A Punnett square or genetic diagram showing the following gametes and offspring <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td></td> <td>D</td> <td>d</td> </tr> <tr> <td>d</td> <td>Dd</td> <td>dd</td> </tr> <tr> <td>d</td> <td>Dd</td> <td>dd</td> </tr> </table> <ul style="list-style-type: none"> mother gametes = d, d father gametes = D, d offspring = 50% Dd, 50% dd probability of offspring with sickle cell disease = 50% probability of carrier / heterozygous = 50% both parents will give one allele to the possible offspring the father can give either the dominant or recessive allele the mother can only give a recessive allele a dominant and recessive allele will result in heterozygous offspring | | D | d | d | Dd | dd | d | Dd | dd | (6) |
| | D | d | | | | | | | | | |
| d | Dd | dd | | | | | | | | | |
| d | Dd | dd | | | | | | | | | |

| Level | 0 | No rewardable content |
|-------|-------|---|
| 1 | 1 - 2 | <ul style="list-style-type: none"> Limited written explanation is provided by the candidate of the inheritance and / or a genetic diagram/ Punnett square with only correct gametes or offspring the answer communicates ideas using simple language and uses limited scientific terminology spelling, punctuation and grammar are used with limited accuracy |
| 2 | 3 - 4 | <ul style="list-style-type: none"> The genetic diagram/ Punnett square is correct for both gametes and offspring with a simple explanation the answer communicates ideas showing some evidence of clarity and organisation and mostly uses scientific terminology appropriately spelling, punctuation and grammar are used with some accuracy |
| 3 | 5 - 6 | <ul style="list-style-type: none"> The Punnett Square/genetic diagram is complete and accurate for both gametes and offspring plus percentage outcomes and a detailed explanation of inheritance of CF the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately spelling, punctuation and grammar are used with few errors |