Question number	Answer	Mark
1(a)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (1 mark): • 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)**

Question number	Answer	Mark
1(b)(i)	An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (1 mark): • 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)**

Question number	Answer	Mark
1(b)(ii)	An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (1 mark): • introduces variation into the population • which allows for natural selection of fitter plants/increased chance of the population surviving	**(2)**

Question number	Answer	Mark
1(c)(i)	C	**(1)**

Question number	Answer	Mark
1(c)(ii)	An explanation that combines identification via a judgement (1 mark) to reach a conclusion via justification/reasoning (1 mark): • genotype is X^DX^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)**

Question number	Answer	Mark
2(a)(i)	B	(1)

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

Question number	Answer	Additional guidance	Mark
2(a)(iii)	• 3.33×10^{-10} equals 0.33 nm (1) • $0.33 \times 250 = 82.5$ (nm) (1)	maximum one mark if no conversion to nm award full marks for correct numerical answer without working	(2)

Question number	Answer	Additional guidance	Mark
2(b)(i)	• heterozygous	accept alleles showing heterozygous genotype	(1)

Question number	Answer	Mark
2(b)(ii)	• correct Punnett square (1) • 75% normal fur pigmentation (1)	(2)

	A	a
A	AA	Aa
a	Aa	aa

Question number	Answer	Mark
2(c)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (1 mark): • both parents must be heterozygous for the recessive allele (1) • so the offspring must inherit the recessive allele from each parent (1)	(2)

Question Number	Answer	Acceptable answers	Mark
3(a)(i)	**D** ☒ homozygous recessive		(1)

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

Question Number	Answer	Acceptable answers	Mark
3(b)(i)	 correct gametes (1) correct offspring genotypes (1)	 **Allow ECF for incorrect gametes**	(2)

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)	An explanation linking **two** of the following: • 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)	accept ratios or probabilities instead of percentages actual offspring are 75% accept references to random assortment	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(a)(iii)	<table><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> Probability = 50% Ratio 2/4, 2:2, can be given for probability 1 mark for correct gametes 1 mark for completed Punnett square with correct probability	Accept reverse order for gametes Accept letters other than B/b (but alleles must be the same letter) 50% mark can only be given if 50% of the offspring are homozygous recessive	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(a)(iv)	**A** ☒ homozygous dominant (BB)		**(1)**

<table>
<tr><th colspan="2">Question Number</th><th>Indicative Content</th><th>Mark</th></tr>
<tr><td>QWC</td><td>*4(b)</td><td>A explanation to include some of the following points:

Pedigree analysis would show the likelihood of their offspring inheriting the disorder
Pedigree analysis should also be carried out on the partners of the third generation.
• 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
Example Punnett square:

<table><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>B</td><td>bb</td></tr></table></td><td>(6)</td></tr>
<tr><td>Level</td><td>0</td><td colspan="2">No rewardable content</td></tr>
<tr><td>1</td><td>1 - 2</td><td colspan="2">• 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</td></tr>
<tr><td>2</td><td>3 - 4</td><td colspan="2">• 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</td></tr>
<tr><td>3</td><td>5 - 6</td><td colspan="2">• 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</td></tr>
</table>

Total for Question 4 = 12 marks

Question Number	Answer	Acceptable answers	Mark
5a (i)	D - ff		**(1)**

Question Number	Answer	Acceptable answers	Mark
5a (ii)	An explanation linking two of the following: • 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)**

Question Number	Answer	Acceptable answers	Mark
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)	An explanation to include two of the following: • 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)	An explanation including the following points: • A Punnett square or genetic diagram showing the following gametes and offspring • 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	**(6)**

	D	d
d	D	dd
d	D	dd

Level	0	No rewardable content
1	1 - 2	• 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	• 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	• 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