HELICATE · A-LEVEL BIOLOGY · TOPIC BANK

3.7.1 Inheritance

Mark scheme

Version 3 · 15 October 2026

TOTAL MARKS	QUESTIONS
62	9

How to use this mark scheme

;	Separates marking points. Each semicolon marks the end of one creditable point, and each point is worth one mark.
;;	Two marks for this answer (used for calculations).
/	Alternative words or phrases that are credited for the same point.
OR	An alternative answer for the same mark.
( )	Words in brackets are not needed to gain the mark.
max	More marking points are listed than marks available. Award up to the number of marks shown.
Accept	An alternative answer that gains credit.
Reject	A wrong answer. It does not gain credit and cancels a correct point it contradicts.
Ignore	Neither credited nor penalised. Mark the rest of the answer.
ECF	Error carried forward: credit correct working that uses an earlier wrong answer.
AO	Assessment objective: AO1 knowledge and understanding; AO2 applying knowledge; AO3 analysing, interpreting and evaluating.

Where an answer is correct but not listed, credit it if it is biologically accurate and answers the question at the depth the marks require. Right + wrong = wrong: a contradiction cancels a correct point.

Monohybrid inheritance and multiple alleles 3.7.1

Question	Marking guidance	Mark	Comments
01.1	It is heterozygous for coat colour, and both alleles are expressed in its phenotype;	**1** (1 × AO1)	Roan cattle are heterozygous (C^RC^W); the alleles are codominant, so both are expressed.

Question	Marking guidance	Mark	Comments
01.2	50%;	**1** (1 × AO2)	C^RC^W × C^RC^R gives C^RC^W (roan) and C^RC^R (red) in a 1 : 1 ratio, so 50% roan.

Question	Marking guidance	Mark	Comments
01.3	1. Red cattle are C^RC^R and white cattle are C^WC^W OR red and white cattle are homozygous (so each produces only one type of gamete); 2. So all their calves are C^RC^W/heterozygous and so roan; 3. Roan cattle are heterozygous/C^RC^W, so each produces both C^R and C^W gametes; 4. So only half/50% of calves from roan × roan are roan;	**3 max** (1 × AO1) (2 × AO2)	**Accept** a correct genetic diagram or Punnett square showing the gametes and offspring for points 1–4 **Accept** other symbols for the alleles if used consistently 3. Must refer to the gametes/alleles passed on by roan parents; a phenotype ratio alone does not gain point 3 4. **Accept** 1 red : 2 roan : 1 white for point 4 only **Reject** 'roan is dominant' or 'red is recessive'

Question	Marking guidance	Mark	Comments
01.4	1. Expression/appearance/characteristic (eg coat colour) due to the genotype/alleles; 2. (And due to) interaction with the environment (eg sunlight makes the hairs paler);	**2** (2 × AO1)	1. **Accept** homozygous/heterozygous/genes/DNA for genotype 1. **Accept** named characteristic, eg red/roan coat Genotype and environment without 'expression' or an equivalent = 1 mark **Ignore** chromosomes **Reject** 'the appearance of a characteristic' with no reference to genotype or environment for point 1

Question	Marking guidance	Mark	Comments
02.1	(Rabbits are diploid, so) one allele at the locus on each chromosome of a homologous pair OR the gene is at one locus and there are only two copies of the chromosome;	**1** (1 × AO1)	**Accept** 'a rabbit has only two copies of each gene' **Ignore** 'one allele from each parent' unless linked to two copies of the chromosome/gene Penalise 'gene' for 'allele' once only if the meaning is lost

Question	Marking guidance	Mark	Comments
02.2	1. $c^{ch}c$ **and** $c^{h}c$; 2. $c^{ch}c^{h}$, $c^{ch}c$, $c^{h}c$ **and** cc; 3. Chinchilla, Himalayan **and** albino **and** ratio 2 : 1 : 1 (chinchilla : Himalayan : albino);	**3** (3 × AO2)	1 and 2. **Accept** the alleles in any order within a genotype, and answers not on the answer lines **Accept** gametes and offspring genotypes shown in a Punnett square 3. **Accept** equivalent ratios, eg 4 : 2 : 2, and phenotypes in any order if matched to the ratio 3. **Accept** 1 chinchilla : 1 chinchilla : 1 Himalayan : 1 albino as equivalent to 2 : 1 : 1 3. **Reject** 1 : 1 : 1 : 1 for four different phenotypes Principle mark: if no mark is awarded, allow 1 mark for correct offspring genotypes from incorrect parental genotypes

Question	Marking guidance	Mark	Comments
02.3	1/16;	**1** (1 × AO2)	Probability of one albino offspring = 0.25; 0.25 × 0.25 = 1/16

Question	Marking guidance	Mark	Comments
03.1	1. A green-stemmed plant must be homozygous recessive/aa, so it passes on only the recessive allele/a; 2. So each offspring's stem colour shows which allele it received from the purple-stemmed plant OR any green-stemmed offspring show the purple-stemmed plant is heterozygous/Aa; 3. A purple-stemmed (pollen) plant could be AA, so a recessive allele from the plant being tested could be masked (and no green offspring appear even if it is Aa);	**2 max** (2 × AO2)	**Accept** 'test cross' for the cross with the green-stemmed plant; naming it alone gains no mark **Accept** 'all purple offspring suggest the plant is homozygous/AA' as part of point 2 **Ignore** 'use a Punnett square' Penalise 'gene' for 'allele' once

Question	Marking guidance	Mark	Comments
03.2	Correct answer for 2 marks: 2.44×10^{-4};; Accept for 1 mark: 0.5^{12} OR 1/4096 OR 0.000244 (not in standard form)	**2** (2 × AO2)	**Accept** 2.4×10^{-4} for 2 marks **Reject** $0.5 \times 12 = 6$ for any mark

Question	Marking guidance	Mark	Comments
03.3	(Almost certainly) homozygous/AA, because a heterozygous plant is very unlikely to produce 12 purple-stemmed offspring;	**1** (1 × AO3)	**Accept** 'probably AA, but she cannot be certain' **Accept** ECF from the answer to 03.2 if a very small probability is given **Reject** 'definitely heterozygous' or 'Aa'

Question	Marking guidance	Mark	Comments
04	1. A^Y/yellow is dominant (to a/agouti), because yellow parents produce agouti offspring OR because heterozygous mice are yellow; 2. All yellow mice/parents are heterozygous/$A^Y a$ (because $A^Y A^Y$ die); 3. Yellow × yellow ($A^Y a \times A^Y a$) gives 1 $A^Y A^Y$: 2 $A^Y a$: 1 aa; 4. $A^Y A^Y$ embryos die, so 2 yellow : 1 agouti are born (209 : 103 ≈ 2 : 1); 5. A quarter of the embryos die, so the mean litter is smaller (5.9 compared with 8.0/8.1, about three-quarters); 6. Yellow × agouti ($A^Y a \times aa$) gives 1 : 1 yellow : agouti OR no $A^Y A^Y$ embryos so no embryos die (normal litter size); 7. Agouti × agouti (aa × aa) gives only agouti/aa offspring;	**5 max** (2 × AO2) (3 × AO3)	**Max 4** if no data from Table 2 are used correctly 4 and 5. **Accept** correct use of the data, eg 209 ÷ 103 = 2.03, or 5.9 ÷ 8.0 = 0.74 **Accept** other symbols for the alleles if used consistently **Reject** 'yellow mice die' OR 'lethal phenotype' for point 4 **Reject** 3 : 1 or 1 : 2 : 1 as the ratio of offspring born from yellow × yellow

Dihybrid inheritance and epistasis 3.7.1

Question	Marking guidance	Mark	Comments
05.1	Epistasis;	**1** (1 × AO1)	**Accept** epistatic and phonetic spellings **Ignore** words before or after, eg 'recessive epistasis' **Reject** codominance, epigenetics, linkage, dominance

Question	Marking guidance	Mark	Comments
05.2	1. (In meiosis) independent segregation/assortment of homologous chromosomes OR the homologous pairs carrying the two genes line up/separate independently of each other; 2. So either allele of gene B is equally likely to enter a gamete with either allele of gene E OR gametes BE, Be, bE and be are produced with a probability of 1/4 each;	**2** (2 × AO1)	1. **Accept** 'random orientation' of homologous pairs 2. **Accept** any equivalent wording for the four combinations **Ignore** crossing over Penalise 'gene' for 'allele' once

Question	Marking guidance	Mark	Comments
05.3	1. BbEe **and** bbEe; 2. BbEE, BbEe, Bbee, bbEE, bbEe, bbee (BbEe and bbEe twice); 3. Black, chocolate **and** yellow **and** ratio 3 : 3 : 2 (black : chocolate : yellow);	**3** (3 × AO2)	1. **Accept** the correct gametes (BE, Be, bE, be and bE, be) instead of the parental genotypes 1 and 2. **Accept** the alleles in any order, eg EbBe, and answers not on the answer lines **Accept** a Punnett square 3. **Accept** equivalent ratios, eg 6 : 6 : 4; phenotypes must be matched to the ratio 3. **Reject** 9 : 3 : 4 or 9 : 3 : 3 : 1 Principle mark: if no mark is awarded, allow 1 mark for correct dihybrid offspring genotypes from incorrect parental genotypes

Question	Marking guidance	Mark	Comments
05.4	1. Both parents are ee/homozygous recessive (for gene E), so all puppies are ee; 2. ee prevents pigment being deposited whatever alleles of gene B they inherit OR gene E masks (the effect of) gene B;	**2** (2 × AO2)	2. **Accept** 'B/b alleles are not expressed in the coat' **Ignore** references to the genotype of gene B alone Penalise 'gene' for 'allele' once

Sex-linkage 3.7.1

Question	Marking guidance	Mark	Comments
06.1	His sons inherit his Y chromosome, not his X chromosome;	**1** (1 × AO1)	

Question	Marking guidance	Mark	Comments
06.2	1. Males (have one X chromosome so) need only one recessive allele (to have the condition); 2. Females need two recessive alleles OR females must be homozygous recessive OR females can be heterozygous/carriers (without the condition);	**2** (2 × AO1)	The answer must refer to alleles: ignore references to X and Y chromosomes alone Use of 'gene' instead of 'allele' throughout = 1 mark max **Reject** 'X allele' or the allele being on the Y chromosome **Ignore** calculations using the survey figures

Question	Marking guidance	Mark	Comments
06.3	1. (Son) 6 has the condition, but neither parent/1 nor 2 does; 2. His X chromosome came from 2, so 2 must have the allele without showing it OR 2 is heterozygous/a carrier; **OR** 3. (Daughter) 8 does not have the condition, but her father 3 does; 4. She must have received the X chromosome/allele from 3, so if it were dominant she would have the condition; **OR** 5. (Son) 12 has the condition, but his mother 8 does not; 6. His X chromosome came from 8, so 8 must have the allele without showing it OR 8 is heterozygous/a carrier;	**2 max** (2 × AO3)	Mark as pairs: 1 with 2, 3 with 4, 5 with 6 **Do not credit** 5, 7, 10 or 11: their phenotypes fit a dominant allele as well as a recessive one **Reject** both 1 and 2 are heterozygous/carriers for point 2 **Reject** if incorrect evidence is given with correct evidence

Question	Marking guidance	Mark	Comments
06.4	Correct answer for 2 marks: 0.25 OR 1/4 OR 25% OR 1 in 4;; Accept for 1 mark: genotypes X^DX^d (8) **and** X^dY (9) **OR** 0.5 (probability that a daughter has the condition; sex not included) **OR** 25 without %	**2** (2 × AO2)	**Reject** ratios, eg 1 : 4 or 1 : 3 **Accept** equivalent fractions, eg 2/8

Autosomal linkage 3.7.1

Question	Marking guidance	Mark	Comments
07.1	1. Genes C and S are on the same chromosome/autosome OR the genes are linked; 2. The plants crossed had C and S on one chromosome and c and s on its homologous chromosome (so C with S and c with s are usually inherited together); 3. So most gametes are CS or cs (parental) and only a few are Cs or cS (recombinant); 4. Cs and cS gametes are produced only when crossing over/a chiasma occurs between the two genes (in meiosis); 5. Crossing over between C and S is rare OR genes C and S are close together on the chromosome;	**4 max** (2 × AO1) (2 × AO2)	3. The mark needs the proportions of gametes, not only of offspring; 'most gametes parental and few recombinant' is one point only 4. **Accept** recombination for crossing over 1. **Accept** alleles of different genes/alleles at different loci on the same chromosome; reject 'alleles' unqualified 1. **Accept** chromatid for chromosome **Ignore** references to independent segregation/assortment **Accept** different letters for the alleles if used consistently

Question	Marking guidance	Mark	Comments
07.2	Correct answer for 2 marks: 4.64 (%);; Accept for 1 mark: 176 ÷ 3792 (× 100) OR a correct answer not to 3 significant figures, eg 4.6	**2** (2 × AO2)	Working: 92 + 84 = 176; 176 ÷ 3792 × 100 = 4.641 95.4 (parental combinations) = 0 marks

Question	Marking guidance	Mark	Comments
07.3	1. Genes C and W are further apart on the chromosome (than C and S) OR C and S are closer together; 2. So crossing over/a chiasma is more likely to occur between C and W OR more recombinant gametes are produced;	**2** (2 × AO3)	2. **Accept** 'more crossing over between C and W' **Reject** 'W is on a different chromosome' (contradicts the stem) **Reject** independent segregation as the explanation

The chi-squared test 3.7.1

Question	Marking guidance	Mark	Comments
08.1	There is no (significant) difference between the observed numbers and the numbers expected from a 9 : 3 : 3 : 1 ratio;	**1** (1 × AO1)	**Accept** 'any difference between the observed and expected (numbers) is due to chance' **Accept** Ho for null hypothesis **Reject** 'there is no difference' with no reference to the expected ratio or numbers

Question	Marking guidance	Mark	Comments
08.2	1. The data are categoric OR the data are numbers/counts in categories/phenotype classes; 2. It compares observed numbers with expected numbers OR it tests the goodness of fit to a ratio;	**2** (2 × AO1)	1. **Accept** 'discrete data' or 'frequencies' **Ignore** 'large sample' **Reject** 'to find a correlation' or 'to compare means'

Question	Marking guidance	Mark	Comments
08.3	Correct answer for 3 marks: 5.83;;; Accept for 2 marks: all four values of $(O - E)^2 \div E$ correct: 0.016, 2.333, 0.583, 2.893 Accept for 1 mark: all four expected numbers correct: 252, 84, 84, 28	**3** (3 × AO2)	**Accept** 5.8 or 5.825 for 3 marks 2 marks: accept values rounded to 2 decimal places (0.02, 2.33, 0.58, 2.89) **Accept** ECF for 2 and 3 marks from one incorrect expected number **Accept** χ^2 or Chi2 for chi-squared

Question	Marking guidance	Mark	Comments
08.4	1. 3 degrees of freedom so the critical value is 7.82; 2. Chi-squared/5.83 is less than the critical value, so the probability that the difference is due to chance is more than 5%/0.05; 3. So no significant difference and accept the null hypothesis OR results fit a 9 : 3 : 3 : 1 ratio (consistent with the genes being on different chromosomes);	**3** (3 × AO3)	**ECF**: allow points 2 and 3 for a correct conclusion from an incorrect value in 08.3 2. Must be 'more than' 5%; reject 0.05%, 50% or 10% 2. **Accept** P for probability 3. **Reject** 'the results are significant' 3. **Reject** 'proves the genes are on different chromosomes'

Question	Marking guidance	Mark	Comments
08.5	1. Phenotype/leaf colour depends on the environment as well as on the genotype; 2. Eg low light could make leaves of YY/Yy plants yellow-green, so seedlings would be placed in the wrong (phenotype) class OR so that differences in phenotype are due only to genotype;	**2** (2 × AO3)	2. **Accept** any suitable example of an environmental effect on stem or leaf colour **Ignore** 'fair test' unqualified

Question	Marking guidance	Mark	Comments
09	1. Cross the two true-breeding/homozygous plants to produce offspring heterozygous for both genes (hairy, normal height); 2. Cross these offspring with hairless rosette plants OR cross these offspring with each other; 3. Grow a large number of offspring (eg 100 or more) in the same conditions; 4. Count/record the number of offspring with each of the four phenotypes; 5. Calculate the expected numbers from a 1 : 1 : 1 : 1 ratio (for a cross with hairless rosette plants) OR a 9 : 3 : 3 : 1 ratio (for a cross between the offspring); 6. Null hypothesis: there is no significant difference between observed and expected numbers; 7. Use chi-squared test with 3 degrees of freedom AND compare the value with the critical value at P = 0.05; 8. If chi-squared is greater than the critical value, reject the null hypothesis; 9. Many more of the parental phenotypes (hairy normal height and hairless rosette) than expected and few recombinant phenotypes show the genes are linked;	**6 max** (3 × AO1) (3 × AO3)	**Max 4** if no analysis (points 5–9) **Max 4** if no breeding plan (points 1–3) 2. **Accept** 'test cross' only if the other parent is identified as homozygous recessive/hairless rosette 3. **Accept** transferring pollen by hand, eg with a brush, and preventing other pollination 9. **Accept** 'genes on the same chromosome' for linked **Ignore** references to independent segregation

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