# Mark schemes

**1**

(a)     0.32.

> *Correct answer = 2 marks*
> *Accept 32% for 1 mark max*
> *Incorrect answer but identifying 2pq as heterozygous = 1 mark*

**2**

(b)     1.     Mutation produced *KDR minus* / resistance allele;
        2.     DDT use provides selection pressure;
        3.     Mosquitoes with *KDR minus* allele more likely (to survive) to reproduce; 4.
               Leading to increase in *KDR minus* allele in population.

**4**

(c)     1.     Neurones remain depolarised;
        2.     So no action potentials / no impulse transmission.

**2**

(a)     1.     (Mutation) changes shape of sodium ion channel (protein) / of receptor(protein);
        2.     DDT no longer complementary / no longer able to bind.

**2**

**[10]**

**2**

(a) 1. (Expression/appearance/characteristic due to) genetic constitution/genotype/allele(s);

*Accept: named characteristic.*

*Accept: homozygous/ heterozygous/genes/DNA.*

*Ignore: chromosomes.*

2. (Expression/appearance/characteristic due to) environment;

**2**

(b) (i) 1. (Individual) 2 has colour vision but 4 is colour blind / 10 has colour vision but 12 is colour blind

OR

4/12 is colour blind but parents have colour vision;

2. So 2/10 must be heterozygous/carriers;

*Accept: (1), 2 and 4 **or** 10, (11) and 12.*

*Accept: any suitable description and explanation equivalent to points 1 and 2.*

*Reject: (both) parents heterozygous/carriers.*

*Accept: correct genotypes for 2 and 10.*

*Accept: for 2 marks, if it was dominant the daughters (8 and 10) of individual 4 would be colour blind.*

**2**

(ii) $X^BX^b$ **or** $X^bX^B$;

*Reject: Bb / bB*

*Accept: XBXb or XbXB;*

*Accept: use of other letter than B*

*e.g. $X^RX^r$, $X^HX^h$.*

**1**

(c) (i) 2 marks for the correct answer of 0.0625 / 6.25% / $\frac{1}{16}$;;

1 mark for incorrect answer but shows 0.03125 / 3.125% / $\frac{1}{32}$;

*Accept: 0.063 / 0.06 / 6.3% / 6% for 2 marks.*

*Accept: incorrect answer but shows / 0.0313 / 0.031 / 0.03 / 3.13% / 3.1% / 3% / ¼ × ¼ / 0.25 × 0.25 for 1 mark.*

*Note: if probability is calculated as a percentage but no % shown in the answer then deduct one mark. For example 6.25 = one mark, 3.125 = zero.*

**2**

(ii) 2 marks for the correct answer of 48(%);;

1 mark for an incorrect answer but shows understanding that 2pq = heterozygous or attempts to calculate 2pq;

*1 mark maximum for the answer of 0.48.*

**2**

**[9]**

**3**

(a) Both alleles are expressed / shown (in the phenotype).

> *Accept: both alleles contribute (to the phenotype)*
> *Neutral: both alleles are dominant*

**1**

(b) Only possess one allele / Y chromosome does not carry allele / gene / can't beheterozygous.

> *Accept: only possess one gene (for condition)*
> *Neutral: only 1 X chromosome (unqualified)*

**1**

(c) 1.  $X^GX^B$,  $X^BX^B$,  $X^GY$,  $X^BY$;

> *Accept: equivalent genotypes where the Y chromosome is shown as a dash e.g. $X^G$-, or is omitted e.g. $X^G$*
> *Reject: GB, BB, GY, BY as this contravenes the rubric*

2.  Tortoiseshell female, black female, ginger male, black male;

3.  (Ratio) 1:1:1:1

> *2 and 3. Award one mark for following phenotypes tortoiseshell, black, (black) ginger in any order <u>with</u> ratio of 1:2:1 in any order.*
> *Allow one mark for answers in which mark points 1, 2 and 3 are not awarded but show parents with correct genotypes i.e. $X^GX^B$ and $X^BY$ **or gametes as** $X^G$, $X^B$ and $X^B$, Y*
> *3. Neutral: percentages and fractions*
> *3. Accept: equivalent ratios e.g. for 1:1:1:1 allow 0.25 : 0.25 : 0.25 : 0.25*

**3**

(d) (i)  Correct answer of 0.9 = 2 marks;

Incorrect answer but shows $q^2 = 0.81$ = one mark.

> *Note: 0.9% = one mark*

**2**

(ii)  Homozygous dominant increases and homozygous recessive decreases.

**1**

**4**

**[8]** (a)  (Recessive) allele is always expressed in females / females have one (recessive) allele / males need two recessive alleles / males need to be homozygous recessive / males could have dominant and recessive alleles / be heterozygous / carriers;

> *Accept: Y chromosome does not carry a dominant allele. Other answers must be in context of allele not chromosome or gene.*

**1**

(b)  (i)  1.  1, (2) and 5;

*Accept: for 1 mark that 1 and 2 have slow (feather production) but produce one offspring with rapid (feather production).*

*Neutral: any reference to 3 being offspring of 1.*

2.  1 must possess / pass on the recessive <u>allele</u> / 1 must be a carrier / heterozygous / if slow (feather production) is recessive all offspring of (1 and 2) would be slow (feather production) / if rapid (feather production) was dominant 1 would have rapid (feather production);

*Reject: both parents must be carriers / possess the recessive allele.*

*Reject: one of the parents (i.e. not specified) must be a carrier / heterozygous.*

**2**

(ii)  $5 = X^fY / X^fY^- / f / f- / fY$ ;

$7 = X^FX^f$ **and** $X^FX^F$ (either way round) /

**or** $X^fX^F$ **and** $X^FX^F$ (either way round) /

**or** $X^FX^f$, $X^fX^F$ **and** $X^FX^F$ (in any order);

*Note: allow $5 = X^fY, X^fY$.*

*Accept: for both 5 and 7 a different letter than F. However, lower case and capital letter must correspond to that shown in the answer. For example accept $7 = X^RX^r$ and $X^RX^R$.*

**2**

(iii)  $X^FX^f$ **and** $X^fY$ **or** $X^fX^F$ **and** $X^fY$ **or** $X^FX^f$ **and** $X^fY^-$ **or** $X^fX^F$ **and**

$X^fY^-$ / **or** Ff **and** fY / **or** Ff **and** $fY^-$ / **or** Ff **and** f- /

**or** Ff **and** f;

*Accept: a different letter than F. However, lower case and capital letter must correspond to that shown in the answer.*

*Accept: each alternative either way round.*

**1**

(c)  Correct answer of 32 (%) = 3 marks;;;

*Accept: 0.32 = 2 marks*

If incorrect answer, allow following points

1.  $p^2 / q^2 = 4\% / 0.04 /$ or $p / q = 0.2$;

2.  Shows understanding that 2pq = heterozygotes / carriers;

*Accept: answer provided attempts to calculate 2pq. This can be shown mathematically i.e. 2 x two different numbers.*

**3**

**5**

2.   Number / sample size may vary;

2

(b)   1.   Increased chance of (severe malaria) with blood group A / decreased chance of (severe malaria) with sickle cell;

*Accept: converse for mild malaria i.e. increased chance of mild malaria with sickle cell / decreased chance of mild malaria with blood group A.*

*Accept: if answer is comparative e.g. greatest risk of severe malaria with blood group A.*

2.   One mark for one of the following:

almost equal chance with blood group O / slightly greater chance of mild malaria with O / slightly lower chance of severe malaria with O / 2.5 x / 2.48 x / more than twice the chance of severe with blood group A / (almost) 50% / half the chance of severe malaria with sickle cell / twice the chance of mild malaria with sickle cell;

*Neutral: answers which only refer to or use ratios.*

2

(c)   1.   Individuals with the **Hb**$^C$ (allele) reproduce;

2.   Pass on **Hb**$^C$ (allele) which increases in frequency;

3.   **Hb**$^A$ **Hb**$^A$ individuals less likely to survive / reproduce / frequency of **Hb**$^A$ (allele) decreases;

3

**[7]**

**6** 1.   Use 1 in 400 to find frequency of homozygous recessive / $q^2$

*OR*

1 in 400 gives frequency of 0.0025;

*Note - convention has recessive allele as q and dominant allele as p but allow reversal (since outcome is the same) as long as this is consistent throughout*

2.   Find square root of $q^2$ / find square root of 0.0025;

3.   Use of $p + q = 1.0$ / determine frequency of both alleles / both $p$ and $q$ / find $p = 0.95$ and $q = 0.05$;

4.   Use of $2pq$ to find carriers / heterozygotes;

*The question requires a description but credit working where
correct as alternative since this shows the stages*

**[3]** (a)  Is always expressed / shown (in the phenotype);

**7**

*Reject 'is always present' without further qualification*

**1**

(b)  $C^BC^B$, $C^BC^P$ and $C^BC^Y$;

*All three are required for the mark*

Or

$C^BC^B$, $C^PC^B$ and $C^YC^B$;

*Accept $C^BC^B$, $C^BC^P$, $C^BC^Y$,*

*$C^YC^B$ and $C^PC^B$*

*Accept BB, BP and BY <u>or</u>*

*BB, BP, BY, YB and PB*

**1**

(c)  1.  Two genotypes (as parents) shown as $C^P$ $C^Y$

*Award **one mark maximum** for candidates who have misread the
question and complete a correct genetic cross between a pink
snail,*
*$C^PC^Y$ and a yellow snail, $C^YC^Y$ to give pink and yellow offspring*

Or

Two sets of gametes shown as $C^P$ and $C^Y$;

2.  Genotypes of offspring shown as $C^P$ $C^Y$, $C^P$ $C^P$ and $C^Y$ $C^Y$;

3.  Above genotypes of offspring correctly linked to phenotypes i.e. pink andyellow;
*Accept ratio (or equivalent) of 3 pink: 1 yellow for mark point 3*

**3**

(d)  1.  Correct answer of 42% = 3 marks
*Answer of 0.42 = 2 marks*
*Award **one mark maximum** for answer of*
*49.9 / 49.98 / 50% or 0.49 / 0.5*

2.  $q^2 = 0.49 / 49\%$ **OR** q = 0.7 / 70%
*Award **one mark maximum** for answer of 40.8 / 41% or 0.41*

3.  Shows understanding that 2pq = heterozygotes / carriers / shows answer isderived
from 2pq;

*Accept: $b^2 = 0.49 / 49\%$ or $b = 0.7 / 70\%$ for mark point 2*

**3**

**[8]** (a)   (i)     Two marks for correct answer of 4;;

**8**

One mark for calculation involving 0.2 × 0.2 or 0.04;

**2**

      (ii)    0.2 / the frequency remains the same;

            *Reject if wrong frequency is quoted*

**1**

(b)   (i)    1.    There is a <u>probability</u> of 5% / 0.05;

               2.    That difference in frequencies / difference in results are due to <u>chance</u>;

                   *Accept 95% probability changes in frequencies not different as a result of chance*

**2**

      (ii)    1.    Directional;

               2.    The recessive allele confers disadvantage / the dominant allele confers advantage / more likely to survive / reproduce;

                   *Assume "it" to refer to the recessive allele*

                   *2. References to selection do not gain credit as the term is in the question. Allow reference to phenotype / enzyme functionality (instead of allele) when describing advantage / disadvantage.*

**2**

**[7**

**] (a)   (i)     Only expressed / shown (in the phenotype) when homozygous / two (alleles) are**

**9** present / when no dominant allele / is not expressed when heterozygous;

**1**

      (ii)    Both alleles are expressed / shown (in the phenotype);

            *Allow both alleles contribute (to the phenotype).*

**1**

(b)   (i)    <u>Evidence</u> (not a mark)

            3 and 4 / two Rhesus positives produce Rhesus negative child / children / 7 / 9;

            <u>Explanation</u> (not a mark)

            <u>Both</u> Rhesus positives / 3 <u>and</u> 4 carry recessive (allele) / are heterozygous / if Rhesus positive was recessive, all children (of 3 and 4) would be Rhesus positive / recessive;

               *Do not negate mark if candidate refers to gene rather than allele.*

*Answers including correct and incorrect evidence = zero marks evidence and explanation.*

**2**

    (ii)    <u>Evidence</u> (not a mark)

3 would not be / is Rhesus positive / would be Rhesus negative;

<u>Explanation</u> (not a mark)

3 would receive Rhesus negative (allele) on X (chromosome) from mother / 3 could <u>not</u> receive Rhesus positive (allele) from mother / 3 would not receive Rhesus positive (allele) / X (chromosome) from father / 1 / 3 will receive Y (chromosome) from father / 1;

**OR**

<u>Evidence</u> (not a mark)

9 would be Rhesus positive / would not be / is Rhesus negative / 8 and 9 / all daughters of 3 and 4 would be Rhesus positive;

<u>Explanation</u> (not a mark)

As 9 would receive X chromosome / dominant allele from father / 3;

*Do not negate mark if candidate refers to gene rather than allele.*

*One mark for evidence and one mark for explanation linked to this evidence.*

*Any reference to allele being on Y chromosome negates mark for explanation.*

**2**

(c)    Correct answer of 48(%) = 3 marks;;;

$q^2$ / $p^2$ = 16% / 0.16 / p / q = 0.4;

Shows that 2pq = heterozygotes / carriers;

*Final answer of 0.48 = 2 marks*

*Allow mark for identifying heterozygotes if candidate multiplies incorrect p and q values by 2.*

**3**

**[9]**

**10**

(a)    The frequency / proportion of <u>alleles</u> (of a particular gene);

Will stay constant from one generation to the next / over generations / no genetic change over time;

Providing no mutation / no selection / population large / population genetically isolated / mating at random / no migration;

*The three principles for marking are:*
*What feature*
*What happens to it*
*Providing . . .*
*Accept: genotype / explanation of genotype*
*Accept: alternative wording, e.g. there is no gene flow / genetic drift*
*for genetically isolated.*

**3**

(b)    White / deaf cats unlikely to survive / selected against;

Will not pass on allele (for deafness / white fur) (to next
generation) / will reduce frequency of allele;

*Accept: alternative wording, e.g. have a disadvantageous*
*phenotype*

*Neutral: will not breed*

**2**

(c)    In Paris / London frequencies (of these alleles) add up to more than 1;

*Can be shown by correct figures to be more than 1*
*e.g. 0.71 + 0.78 = 1.49*
*Accept: more than 100%*

**1**

(d)    Two marks for correct answer of 44(.22);;

One mark for incorrect answer in which p / frequency of H
determined as 0.67 and q / frequency of h as 0.33

***OR***

Answer given as 0.44(22);

**2**

**[8]**

(a)    Parents genotypes                Aabb                aaBb            ;

**11**

Gametes formed            Ab      ab            aB      ab ;
        *if parental genotypes wrong allow correctly derived gametes only*

Offspring genotypes      AaBb      Aabb      aaBb      aabb

        ***and***

Offspring phenotypes 1  Walnut ;    1 Pea :   1 Rose :   1 single ;
        *Just **one** mark for offspring genotypes **and** phenotypes*
        *If parents not diploid, no marks gained*

**3**

(b)    Correct answer 0.6, however derived, scores 2 marks
Wrong answer, but evidence of correct working
(e.g. $p^2 / q^2 = 0.36$) scores 1 mark

**2**

**[5]** (a)    1. frequent use of antibiotic creates selection pressure / antibiotic kills bacteria;

# 12

2. bacteria with mutation / resistance have (selective) advantage over others / described;
3. (survive to) reproduce more than other types pass on advantageous allele / mutated allele in greater numbers;
4. frequency of (advantageous) allele increases in subsequent generations;

        *(penalise use of "gene" instead of allele once only)*
5. frequency of resistant types increases in subsequent generations;

**5**

(b)    correct answer = 0.18; And
three marks for three of: $p + q$
= 1 and $p^2 + 2pq + q^2 = 1$;

$0.01 = q^2$ ; $q = 0.1$; $p = 0.9$ frequency of heterozygotes = $2pq = 2$
× 0.1 × 0.9 / 2 × candidates $p$ × candidates $q$;

**4 max**

**[9]** (a)    Population – organisms of one species in an ecosystem / habitat / area;

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Community – organisms of all species / all populations in an
ecosystem / habitat / area;

**2**

(b)    (i)    No immigration / migration (Ignore references to emigration);
No reproduction *(Ignore references to death)*;
Idea of mixing;
Marking does not influence behaviour / increase vulnerability
to predation;
Sample / population large enough;

**max 2**

(ii)    $\dfrac{96 \times 77}{11}$ ; 672;
*Correct answer (however derived) scores 2 marks*
*Incorrect answer with evidence of correct method scores 1 mark.*

**2**

(c)     Principle of randomly placed quadrats and method of producing randomquadrats;                    **3**
        *(Reject 'throwing')*
        Valid method of obtaining no. dandelions in given area (mean per
        quadrat / total no. in many quadrats);
        Multiply to give estimate for total field area;


(d)     (i)     Niche of A – 1;                                                                            **2**
                Niche of B – 3;
                Too small for B / too hot for A – 4;
                Too large for A / too cold for B – 2;
                *All four correct = 2 marks; any 2 correct = 1 mark*


        (ii)    Original population living in one area / 2 species evolved in
                the area;
                Idea of genetic variability;                                                              **max 4**
                Concept of reproductive isolation;
                Possible mechanism;
                Gene pools become increasingly different;
                Until interbreeding does not produce fertile offspring;




                                                                                                          **[15]**

**14**  (a)     Mutation / (spontaneous) change in a gene / change in DNA;                                 **1**


(b)     (i)     Correct answer: 0 / 6;;                                              2 marks
                OR

Use of 56 and $\dfrac{176}{2}$

                  or 88 / $\underline{56 \times 2}$ or 112 <u>and</u> 176;    1 mark        **max 2**

(ii)  64;                                                                      **1**

(c)  (i)  Correct answer = 42%;;;  (only if $q^2 = 0.49$)      3 marks

        OR 0.42;;                                            2 marks

        OR

        $p + q = 1$ / $p^2 + 2pq + q^2 = 1$ / $p = 1 - 0.7$ / $q^2 = 0.49$ / $q = 0.7$;

        Answer = $2pq$ / use of appropriate numbers;      2 marks

                                                                         **max 3**

(ii)  1. Parental genotypes correct: both $W^R W^S$

        (ACCEPT 'RS')

      AND

      $W^S$ (ACCEPT 'S') / gamete from each parent;

      2. $W^S W^S$ (ACCEPT 'SS') / offspring formed and identified as susceptible;
      <u>If different symbols:</u>
      – defined  :        max 2 marks
      – not defined     max 1 mark (= pt.2)

                                                                               **2**

(iii)  1. <u>Description</u>: decrease + rate of decrease slows with time;

      Explanation: Any **three** from:

      2. Resistant rats / rats with $W^R$ allele survive
          <u>OR</u> susceptible / $W^S W^S$ rats killed

      3. (more likely) to pass on $W^R$ allele to offspring / less likely to pass on $W^S$ /
          higher proportion of next generation has $W^R$ allele / lower proportion has $W^S$;

      4. Chance of mating with $W^S W^S$ is reduced / $W^S W^S$ becomes rare;

      5. Rate of selection against $W^S$ slows because $W^S$ allele is in    heterozygotes;
                                                                         **max 4**

(iv)  No selective advantage / All genotypes equally fertile;
      Large population;
      Random mating; (IGNORE 'random fertilisation')
      No mutation;
      No emigration / immigration;

                                                                                 **max 2**

                                                                 **[15]** (a)    Gg / suitable equivalent;

**15**

Grey : black about 3: 1;

*[Note: Can be in table / diagram]*

2

(b)  To determine the probability;

*[Accept: Likelihood]*

Of the results being due to chance;

*[Accept: Coincidence]*

2

(c)  (i)  both alleles will be expressed (in the phenotype);

1

(ii)  0.25 / 25%; = 2 marks

$C^N$ = 250 / 1000; = 1 mark

2

(iii)  $P^2$ = (0.25)$^2$ / 0.0625 / square of calculated figure for $C^N$; = 2 marks $p^2$ +2$pq$ + $q^2$ = 1.0; = 1 mark

= 31.25 / 31;

*[Accept: Derived from either $p^2$ or $q^2$]*

3

**[10]**