Level 1 Science

Demonstrate understanding of aspects of unicorns

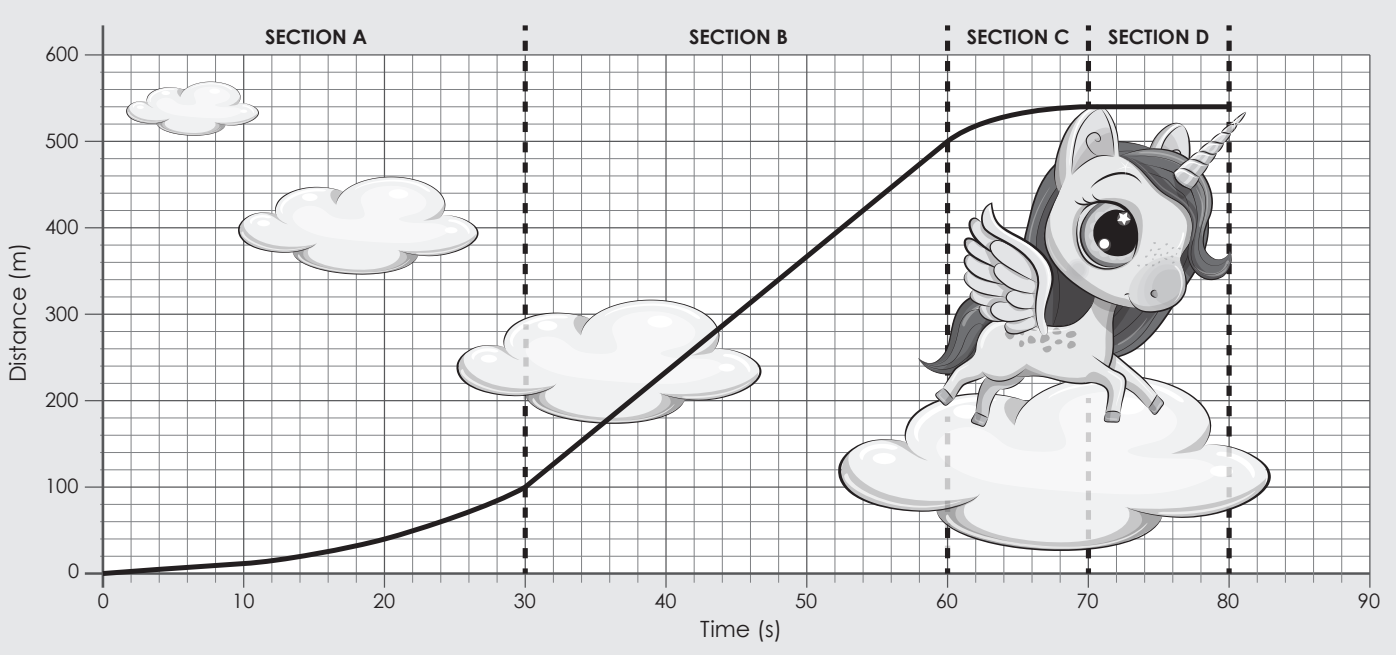
Credits: Four pixie dust fairy sprinkles and a bag of candy floss

For Assessor's use only	**Achievement Criteria**			
Achievement		**Achievement with Merit**		**Achievement with Excellence**
Demonstrate understanding of aspects of unicorns.	☐	Demonstrate an in-depth understanding of aspects of unicorns.	☐	Demonstrate comprehensive understanding of aspects of unicorns. ☐

UNICORN MECHANICS

QUESTION ONE

The graph below shows the motion of *Stardust Sprinkleshine* as she rides on white fluffy marshmallow clouds.



(a) Describe the **motion** of *Stardust Sprinkleshine* in each section of the graph. No calculations are required.

Section A: _____

Section B: _____

Section C: _____

Section D: _____

(b) Calculate the **speed** of *Stardust Sprinkleshine* in **Section B** of the graph.

_____

_____

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_____

(c) Explain why *Stardust Sprinkleshine's* hooves sink further into the marshmallow cloud when she stands on two legs as opposed to four legs. In your answer you should consider the **pressure** applied and the forces acting. No calculations are necessary.

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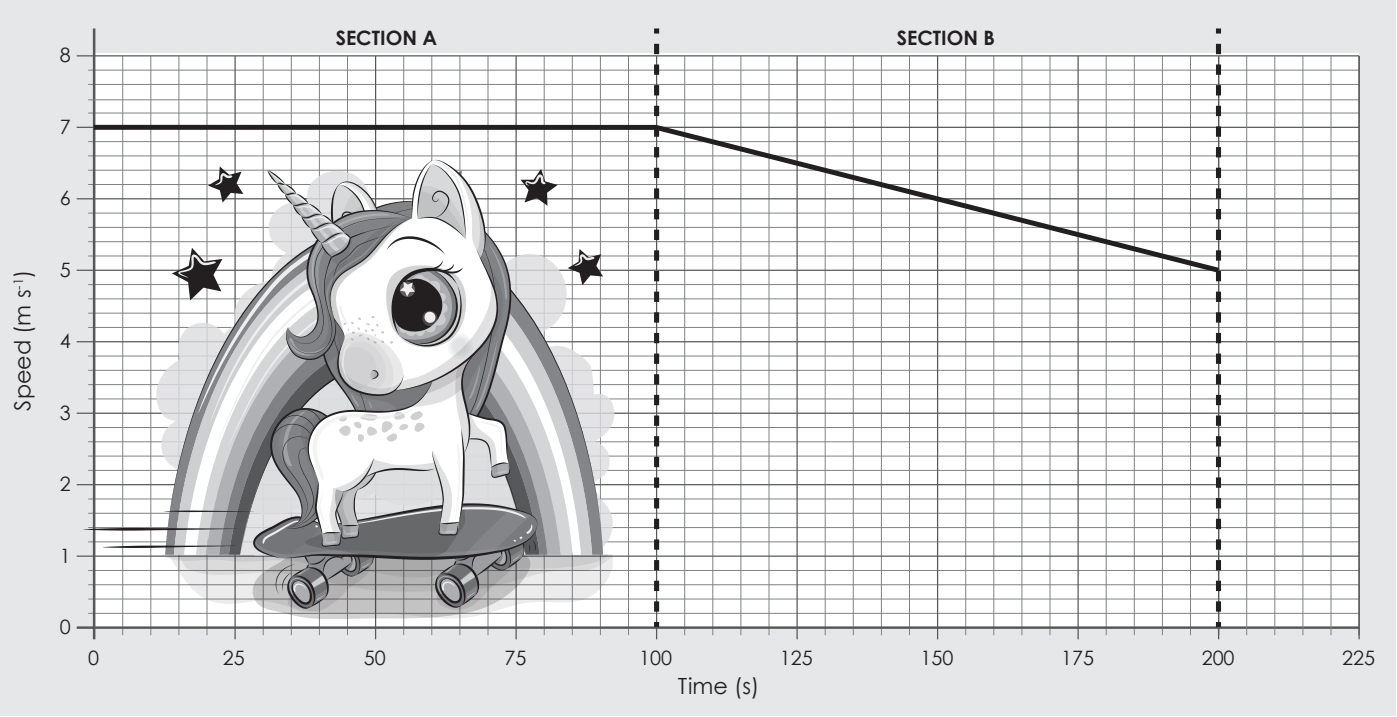
QUESTION TWO

Clementine Sparkle Buttercup likes to skate. The speed-time graph below shows part of her journey.



(a) Calculate the **distance** *Clementine Sparkle Buttercup* travelled in the first 100 seconds.

(b) Explain how the **forces** acting on *Clementine Sparkle Buttercup* result in the **motion** shown in the graph (no calculations are needed).

Include reference to the net force.

Section A:

Section B:

QUESTION THREE

According to Unicornpedia, unicorns are made of hugs, surprises giggles, dreams, kindness, kisses and super-glue.

Twinkle Daydream Sugarsocks has a mass of 30 kg.

(a) Explain the difference between **mass** and **weight**.

(b) Calculate *Twinkle Daydream Sugarsocks'* **weight**.

Twinkle Daydream Sugarsocks is a '*pegacorn'*. Pegacorns are winged unicorns. She uses her wings to fly vertically to a marshmallow cloud that is 3.0 m above the ground. This takes her 2 seconds.

(c) Calculate the **work** done by *Twinkle Daydream Sugarsocks* to get to the marshmallow cloud and, therefore, the **power** exerted. Include units in your answer.

Jellybean Bubble Glow is the **same mass** as *Twinkle Daydream Sugarsocks. Jellybean Bubble Glow* is not a pegacorn - she cannot fly. In order to reach the **same marshmallow cloud** she has to walk up a rainbow bridge. The bridge is 4.0 m long. It takes her 4.0 seconds to walk up the bridge.

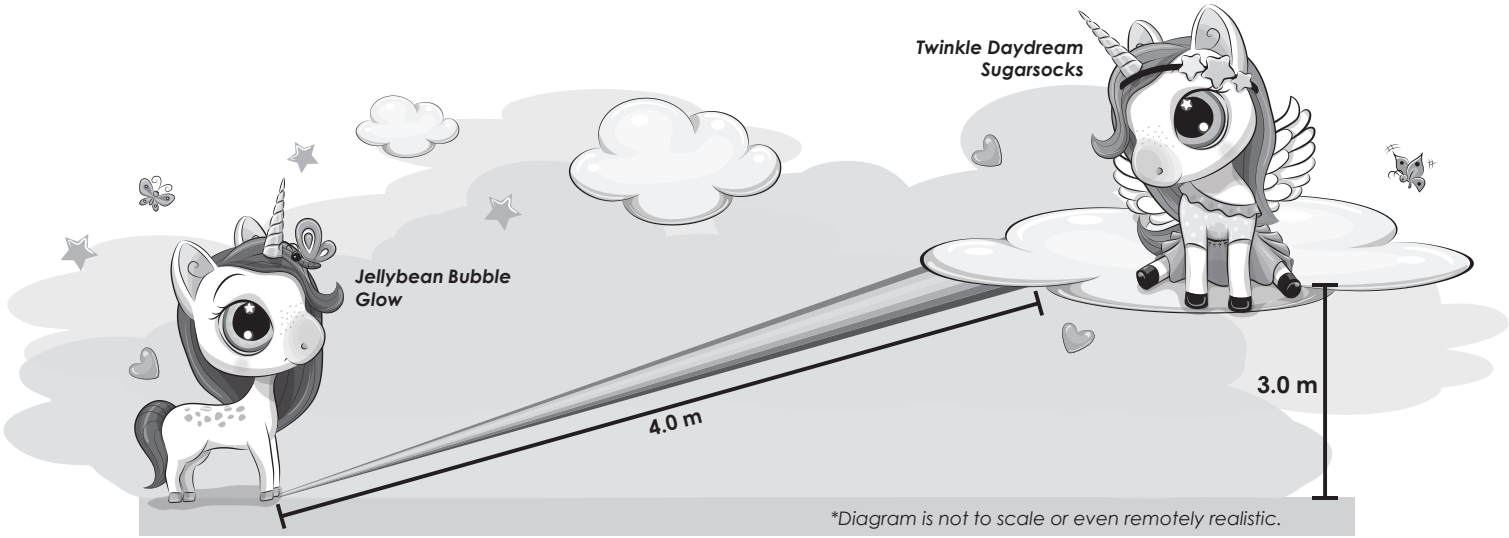


**Diagram is not to scale or even remotely realistic.*

(d) Explain why *Jellybean Bubble Glow* required **less power to walk up the ramp** compared to *Twinkle Daydream Sugarsocks*, who flew up to the marshmallow cloud. Include units in your answer.

(e) State the amount of gravitational potential energy *Jellybean Bubble Glow* has gained now that she is on the marshmallow cloud.

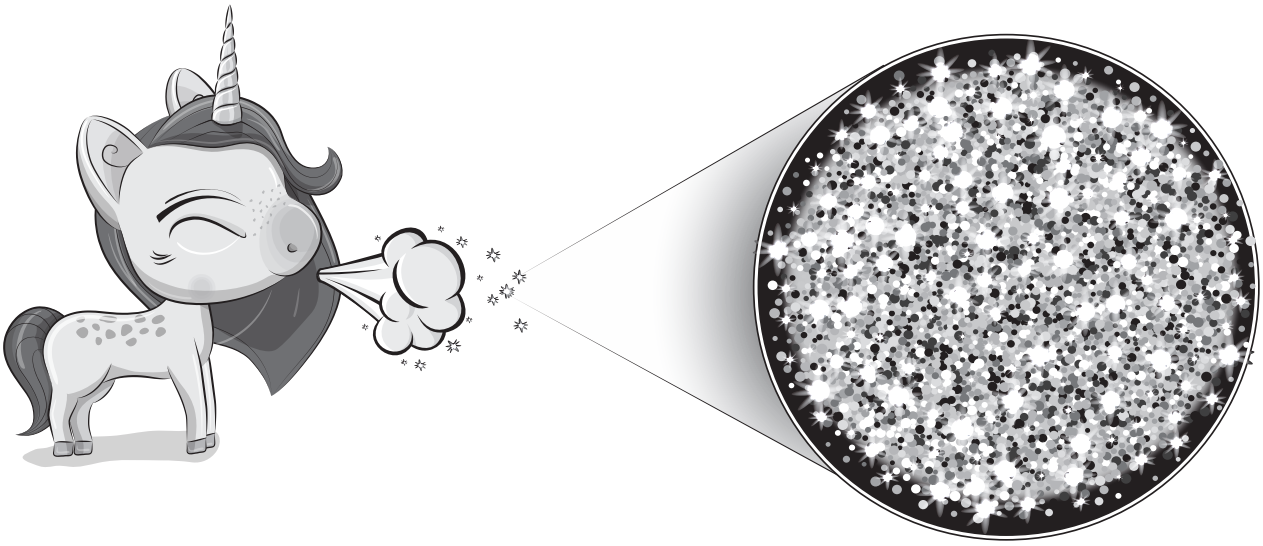
(f) *Jellybean Bubble Glow* was chasing butterflies when she fell off the cloud. Calculate her **velocity** immediately before she hit the ground and spilled all her glitter sparkles.

UNICORN CHEMISTRY

QUESTION ONE

When unicorns sneeze they not only spray hopes and wishes, but also a fine metallic glitter.

A sample of unicorn sneeze was captured and the glitter component was found to contain the metals sodium (Na) and magnesium (Mg).



A rare picture of the particles of sodium and magnesium found in a unicorn sneeze.

(a) Using sodium and magnesium in your answer, explain why atoms are electrically neutral. In your answer, you should:

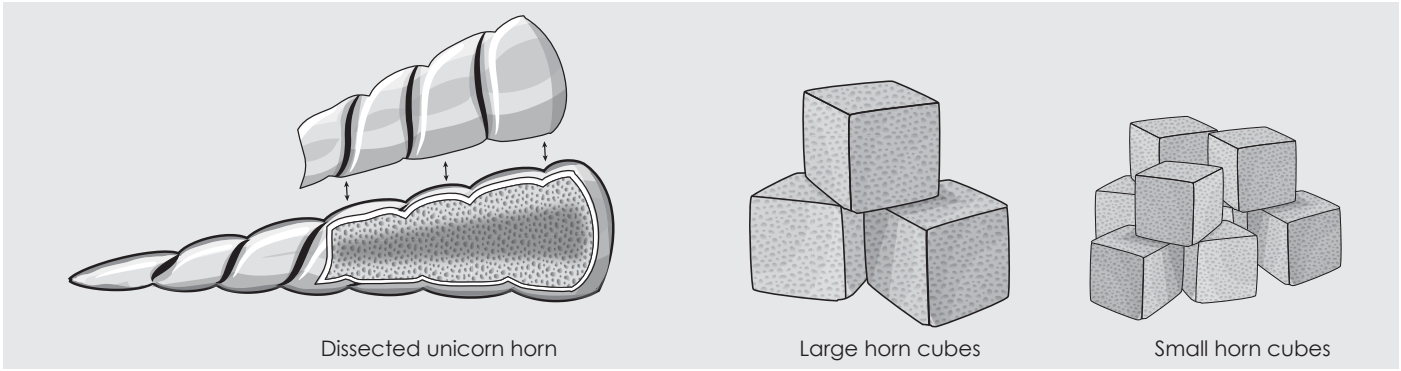
- Fully describe the **atomic structure** of sodium and magnesium.
- State their **electron configurations**.

(b) Explain why the ions in sodium oxide combine to give the formula Na_2O but the ions in magnesium oxide combine to give the formula MgO. In your answer, you should:

- **Compare** the charges on the individual ions found in the compounds sodium oxide and magnesium oxide.
- **Explain** why the ions combine in the ratios the way they do to form the compounds Na_2O and MgO.

QUESTION TWO

A scientist dissected a unicorn horn and found it was made of a **calcium carbonate ($CaCO_3$)**.



Dissected unicorn horn | Large horn cubes | Small horn cubes

She cut some of the unicorn horn into larger cubes and some into smaller cubes. The table below shows the size of unicorn horn (calcium carbonate) cubes used in an investigation into factors affecting rate of reaction.

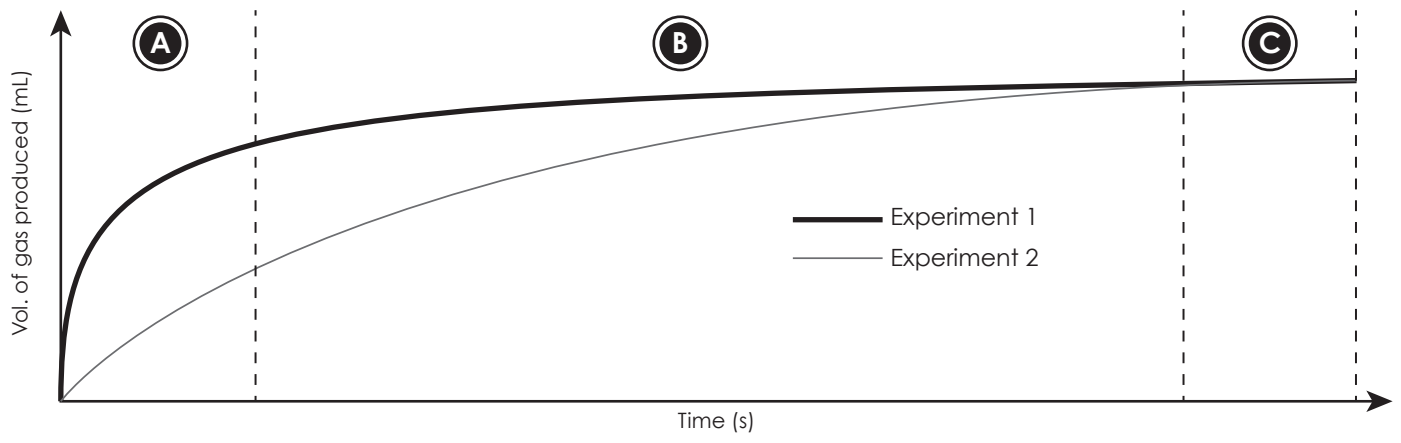
Experiment	**Experiment 1**	**Experiment 2**
Size of unicorn horn cubes	Small cubes	Large cubes

Experiment 1: 10 mL of hydrochloric acid was added to a boiling tube containing small cubes of horn.

Experiment 2: 10 mL of hydrochloric acid of the same concentration and temperature as in Experiment 1 was added to another boiling tube containing large cubes of horn.

In both experiments the total mass of the unicorn cubes was the same.

The boiling tubes were connected to a gas syringe to measure the rate of gas produced by the reaction.



(a) Write a word equation and a correctly balanced symbol equation for the reaction between the unicorn horn (calcium carbonate) and the hydrochloric acid.

Word equation

Correctly balanced symbol equation

(b) State the factor affecting the rate of reaction investigated in these experiments.

(c) Explain what is happening in Experiment 1 in sections A, B, and C of the graph in terms of reaction rate. In your answer you should refer to **particle collisions**.

(d) Explain why Experiment 1 was faster than Experiment 2 in section A. In your answer you should:

- Explain how the graph shows that Experiment 1 is faster.
- Explain how the size of the unicorn horn cubes affects the number of particle collisions.

QUESTION THREE

Unicorn hair behaves in the same manner as universal indicator. Special glands beneath their skin secrete various acids and alkalis which give the unicorn's mane and tail their rainbow colouration.

A scientist put 10 mL of dilute nitric acid in a boiling tube with five hairs from a unicorn tail. Sodium hydroxide of the same concentration was then added. The following observations were recorded.

Volume of sodium hydroxide added (mL)	0	10	20
Colour of unicorn hair	Red	Green	Purple

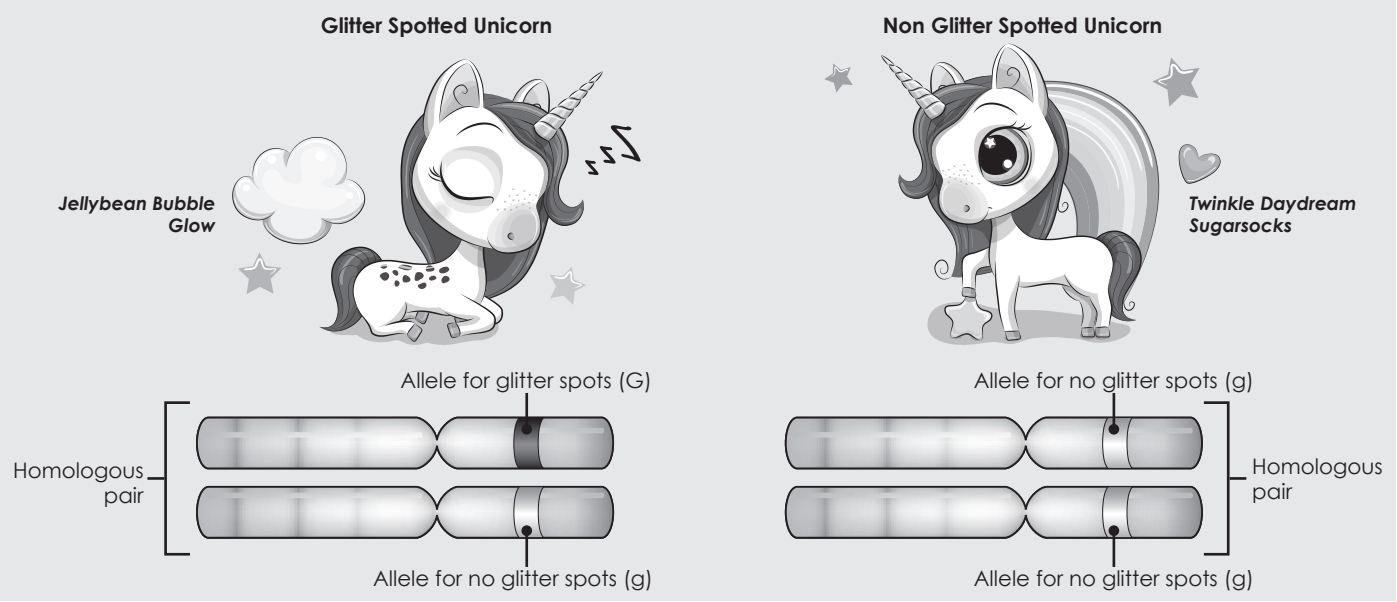
Discuss the reaction occurring as sodium hydroxide is added to the nitric acid. In your answer you should describe the relationship between the colours observed and the pH of the solution, AND to the relative concentration of H^+ and OH^- ions.

UNICORN GENETICS

QUESTION ONE

Unicorns can have either have glitter spots on their coat, or have plain coats with no glitter spots.

The diagrams below show the homologous chromosomes that contain the gene for glitter spots for each of the unicorns. The allele for glitter spots (G) is dominant over the allele for no glitter spots (g).



(a) In the diagram above, state which unicorn is **heterozygous**. _____

Explain why you chose this unicorn.

_____

_____

_____

_____

(b) Referring to the glitter spot pattern, explain the difference between an **allele** and a **gene**.

_____

_____

_____

_____

_____

(c) These two unicorns have the same parents and were produced by sexual reproduction.

Discuss how they have inherited different alleles for the glitter spot pattern. In your answer you should:

- Explain where the homologous chromosomes have come from.
- Give the possible genotypes of both parents and explain how you determined these possible genotypes.
- Included at least one Punnett square.

_____

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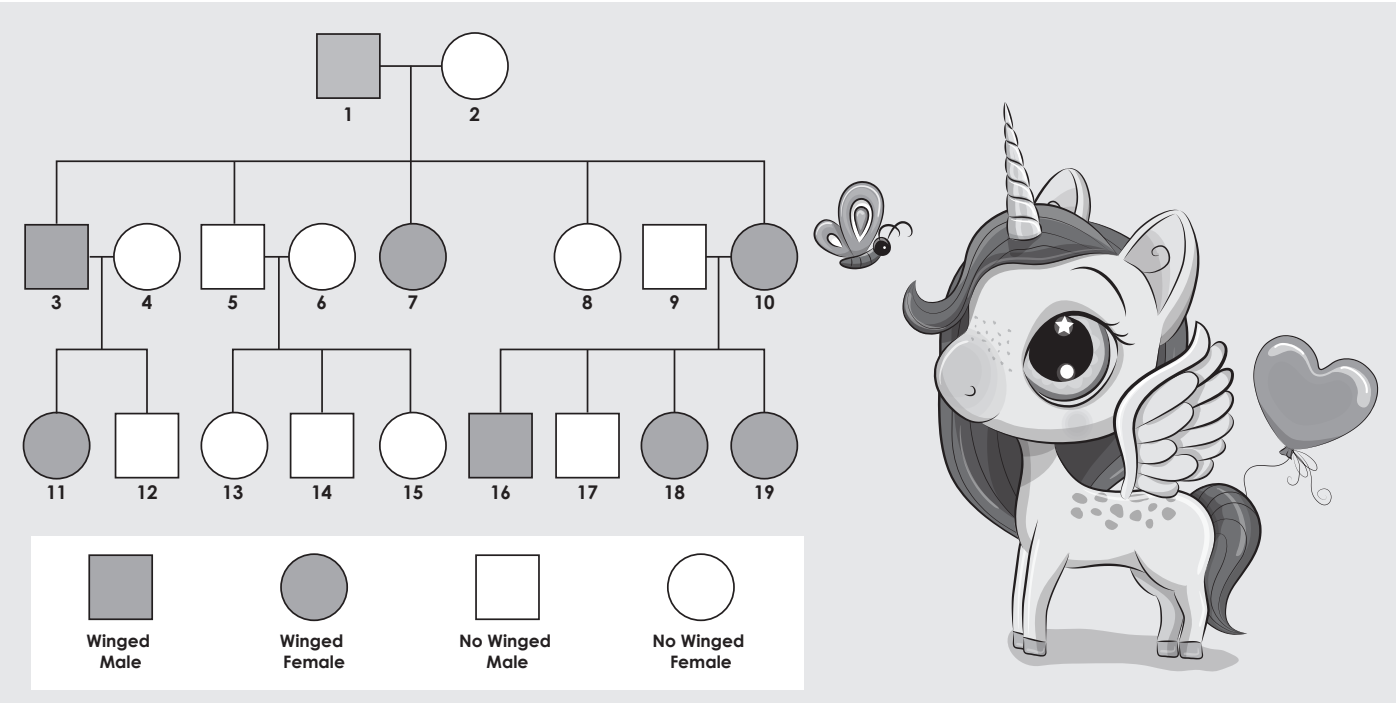
QUESTION TWO

Pegacorns are winged unicorns. Wings are an inherited trait.

Wings are caused by a dominant allele (W). The allele for no wings is recessive (w).



(a) Using the alleles W and w, give the two possible genotypes for a **pegacorn**.

(i) _____

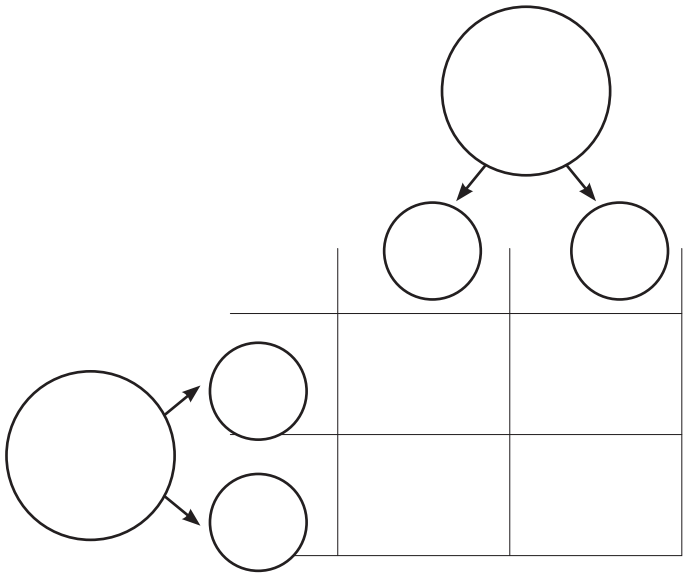
(ii) _____

(b) State the genotype of unicorn 9 in the pedigree chart above. _____

State the genotype of unicorn 10 in the pedigree chart above. _____

Explain how you worked out the genotype for unicorn 10. You should support your answer using evidence from BOTH the parents AND offspring of unicorn 10.

(c) Draw a Punnett square to show the possible genotypes of the offspring from unicorns 9 and 10.



(d) From your Punnett square, predict what fraction of the offspring would be pegacorns (have wings) and what fraction would not have wings.

Fraction of offspring with wings: _____

Fraction of offspring without wings: _____

(e) Using your Punnett square, complete the box below to show the expected phenotype ratio for the offspring.

	Winged unicorns : Non-winged unicorns
Phenotype ratio from Punnett square	:

(f) Give reasons why the predicted ratio in the Punnett square and the observed ratio in the offspring may NOT be the same.

QUESTION THREE

For unicorns, as with all animals, there are advantages and disadvantages to sexual reproduction.

Explain how sexual reproduction contributes to variation in a population of **animals** (such as unicorns). In your answer you should refer to *gametes*, *meiosis* and *fertilisation*.

EXAMINATION RESOURCE SHEET

+1	+2	+3	−3	−2	−1
H^+ Hydrogen	Ca^{2+} Calcium	Al^{3+} Aluminium	P^{3-} Phosphide	O^{2-} Oxide	F^- Fluoride
Na^+ Sodium	Mg^{2+} Magnesium	Fe^{3+} Iron(III)	PO_4^{3-} Phosphate	S^{2-} Sulfide	Cl^- Chloride
Li^+ Lithium	Cu^{2+} Copper			CO_3^{2-} Carbonate	Br^- Bromide
K^+ Potassium	Pb^{2+} Lead			SO_4^{2-} Sulfate	I^- Iodide
NH_4^+ Ammonium	Fe^{2+} Iron(II)				OH^- Hydroxide
Ag^+ Silver	Be^{2+} Beryllium				HCO_3^- Hydrogen carbonate
	Zn^{2+} Zinc				NO_3^- Nitrate
	Ba^{2+} Barium				

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.0																	2 He Helium 4.0
3 Li Lithium 6.9	4 Be Beryllium 9.0											5 B Boron 10.8	6 C Carbon 12.0	7 N Nitrogen 14.0	8 O Oxygen 16.0	9 F Fluorine 19.0	10 Ne Neon 20.2
11 Na Sodium 23.0	12 Mg Magnesium 24.3											13 Al Aluminium 27.0	14 Si Silicon 28.1	15 P Phosphorus 31.0	16 S Sulfur 32.1	17 Cl Chlorine 35.5	18 Ar Argon 40.0
19 K Potassium 39.1	20 Ca Calcium 40.1	21 Sc Scandium 45.0	22 Ti Titanium 47.9	23 V Vanadium 50.9	24 Cr Chromium 52.0	25 Mn Manganese 54.9	26 Fe Iron 55.9	27 Co Cobalt 58.9	28 Ni Nickel 58.7	29 Cu Copper 63.5	30 Zn Zinc 65.4	31 Ga Gallium 69.7	32 Ge Germanium 72.6	33 As Arsenic 74.9	34 Se Selenium 79.0	35 Br Bromine 79.9	36 Kr Krypton 83.8
37 Rb Rubidium 85.5	38 Sr Strontium 87.6	39 Y Yttrium 88.9	40 Zr Zirconium 91.2	41 Nb Niobium 92.9	42 Mo Molybdenum 95.9	43 Tc Technetium 98.9	44 Ru Ruthenium 101	45 Rh Rhodium 103	46 Pd Palladium 106	47 Ag Silver 108	48 Cd Cadmium 112	49 In Indium 115	50 Sn Tin 119	51 Sb Antimony 122	52 Te Tellurium 128	53 I Iodine 127	54 Xe Xenon 131
55 Cs Caesium 133	56 Ba Barium 137	71 Lu Lutetium 175	72 Hf Hafnium 179	73 Ta Tantalum 181	74 W Tungsten 184	75 Re Rhenium 186	76 Os Osmium 190	77 Ir Iridium 192	78 Pt Platinum 195	79 Au Gold 197	80 Hg Mercury 201	81 Tl Thallium 204	82 Pb Lead 207	83 Bi Bismuth 209	84 Po Polonium 210	85 At Astatine 210	86 Rn Radon 222

$$v = \frac{\Delta d}{\Delta t} \qquad a = \frac{\Delta v}{\Delta t} \qquad P = \frac{F}{A}$$

$$W = Fd \qquad F_{net} = ma \qquad E_K = \tfrac{1}{2}mv^2$$

$$g = 10\ N\ kg^{-1} \qquad P = \frac{W}{t} \qquad \Delta E_P = mg\Delta h$$

Demonstrate understanding of aspects of unicorns

SUGGESTED ANSWERS

UNICORN MECHANICS

QUESTION ONE

(a) A: acceleration / increasing speed

B: constant speed

C: deceleration / decreasing speed

D: stationary / constant speed / stopped

(b) $v = d / t$

$= 400 \text{ m} / 30 \text{ s}$

$= 13.3 \text{ ms}^{-1}$

(c) Pressure is a function of a force applied to a given area ($P = F/A$).

The force is the weight of Stardust Sprinkleshine. When this force is applied to the area covered by two of her hooves it will result in a greater pressure on the marshmallow cloud, when compared to the same weight forces applied to the area of four of her hooves.

Because the pressure is greater when she stands on two hooves, she will sink further into the marshmallow cloud.

QUESTION TWO

(a) $d = v \times t$

$= 7 \text{ m s}^{-1} \times 100 \text{ s}$

$= 700 \text{ m}$

(b) Section A: Clementine Sparkle Buttercup has a constant speed (7 m s^{-1}). This means that there is no acceleration. This occurs when the thrust force is equal to friction forces. This results in no overall net force.

Section B: Clementine Sparkle Buttercup decelerates. This occurs when the frictional forces are greater than thrust force. This is because there is an overall net force acting backwards, opposite to the direction of motion.

QUESTION THREE

(a) Weight is the downward force due to gravity that an object experiences, while mass is a measure of the amount of matter that an object has.

(b) $F = ma$

$= 30 \text{ kg} \times 10 \text{ N kg}^{-1}$

$= 300 \text{ N}$

(c) $W = Fd$

$= 300 \text{ N} \times 3 \text{ m}$

$= 900 \text{ J}$

$P = W / t$

$= 900 \text{ J} / 2 \text{ s}$

$= 450 \text{ W}$

(d) Jellybean Bubble Glow

$W = Fd$

$= 300 \text{ N} \times 3 \text{ m}$

$= 900 \text{ J}$

$P = W / t$

$= 900 \text{ J} / 4 \text{ s}$

$= 225 \text{ W}$

Power is a measure of the amount of work done over a period of time. Since Jellybean Bubble Glow took longer (4 s) to do the same amount of work (900 J) she required less power.

(e) $\Delta E_P = mg\Delta h$

$= 30 \text{ kg} \times 10\text{N kg}^{-1} \times 3 \text{ m}$

$= 900 \text{ J}$

(f) $E_P = E_K$

$mgh = 1/2\ mv^2$

$v^2 = 2gh$

$v = \sqrt{(2 \times 10 \text{ N kg}^{-1} \times 3 \text{ m})}$

$= 7.75 \text{ m s}^{-1}$

UNICORN CHEMISTRY

QUESTION ONE

(a) Sodium has 11 protons and 11 electrons which are arranged as 2,8,1.

The number of positively charged protons is equal to the number of negatively charged electrons. Therefore, the atom is electrically neutral.

Magnesium has 12 protons and 12 electrons which are arranged as 2,8,2.

The number of positively charged protons is equal to the number of negatively charged electrons. Therefore, the atom is electrically neutral.

(b) Sodium loses 1 electron to end up with a charge of +1, forming the sodium ion Na^+.

Oxygen has 8 electrons with an electron configuration of 2,6. Oxygen needs 2 electrons in order to gain a full shell of valance electrons, and forms the oxide ion O^{2-}.

In order to have a neutral compound, 2 sodium ions are needed to cancel out the charge on the oxide ion, giving the formula Na_2O

Magnesium loses 2 electrons to end up with a charge of +2, forming the magnesium ion Mg^{2+}. Oxygen needs 2 electrons in order to gain a full shell of valance electrons. In order to have a neutral compound, one magnesium ion is needed to cancel out the charge on the oxide ion, giving the formula MgO.

QUESTION TWO

(a) Calcium carbonate + hydrochloric acid ⟶ calcium chloride + carbonate dioxide + water

$CaCO_3 + 2HCl \longrightarrow CaCl_2 + CO_2 + H_2O$

(b) Surface area.

(c) In section A of the graph the rate is fastest as there are more successful collisions between the HCl and $CaCO_3$ per unit of time. This is because at the start of the reaction there are more $CaCO_3$ and HCl particles available to react.

In section B the rate of reaction is slowing down as the number of particles available for collision, per unit time, is becoming fewer as some of the HCl and $CaCO_3$ have already collided and have been used up, therefore there are fewer reactant particles and therefore fewer collisions.

In section C the reaction has stopped, as all of the reactants (or one of them) have reacted, and therefore there are no particles present that can collide and react.

(d) The rate of Experiment 1 is faster during section A as the slope of the graph is steeper than Experiment 2. It is faster because when smaller cubes are used, the surface area of the cubes is greater. Because there is more surface area, there is more $CaCO_3$ exposed for the HCl particles to collide with. Because there are more collisions occurring more frequently, the rate is faster per unit of time.

QUESTION THREE

Nitric acid is acidic and will make unicorn hair (U.I) appear red. As

the NaOH is added, the nitric acid is being neutralised, then after that the solution becomes more basic.

When no NaOH has been added, the unicorn hair will be red with a pH of 1–2. There is an excess of H^+ ions. As the unicorn hair becomes orange-yellow, the pH will be approximately 4–6. There is still an excess of H^+ ions but not as big an excess as when the pH was lower.

When 10 ml of NaOH has been added, the unicorn hair will be green, with a pH of 7, which is neutral. At this point, the number of H^+ and OH^- ions is equal and they cancel each other out to form water.

After 15 mL has been added, the unicorn hair will appear blue, with a pH of 9–12. There is now an excess of OH^- ions.

When 20 mL has been added, the unicorn hair will be purple, and the pH will be 13–14. There is now a greater excess of OH^- ions than when the unicorn hair was blue.

UNICORN GENETICS

QUESTION ONE

(a) Jellybean Bubble Glow is heterozygous.

(b) Heterozygous means that the genotype of the individual contains two different alleles for a particular trait.

(c) A gene is a length of DNA that codes for a particular characteristic such as glitter spots. An allele is an alternative form of a gene. There is one allele for glitter spots and a different allele for no glitter spots. The two alleles together make up the genotype.

(c) The unicorns have inherited their alleles for glitter spots because they have inherited one homologous chromosome from their mother and one from their father.

The non-glitter spot unicorn is homozygous recessive for non-glitter spots; therefore each parent must have contributed a recessive (g) allele. The glitter spotted unicorn has one non-glitter spot allele; therefore at least one of the parents must have a non-glitter spot allele.

This means there are two possibilities for the parents: they are either both heterozygous (Gg); or one parent is heterozygous (Gg) and the other is homozygous recessive (gg).

	G	g
G	Gg	Gg
g	Gg	gg

	G	g
g	Gg	gg
g	Gg	gg

QUESTION TWO

(a) (i) WW (homozygous dominant)

(ii) Ww (heterozygous)

(b) Unicorn 9 = ww (homozygous recessive)

Unicorn 10 = Ww (heterozygous)

Unicorn 9 is a non-winged male. Since the absence of wings is controlled by a recessive allele (w), this unicorn must be homozygous recessive (genotype = ww).

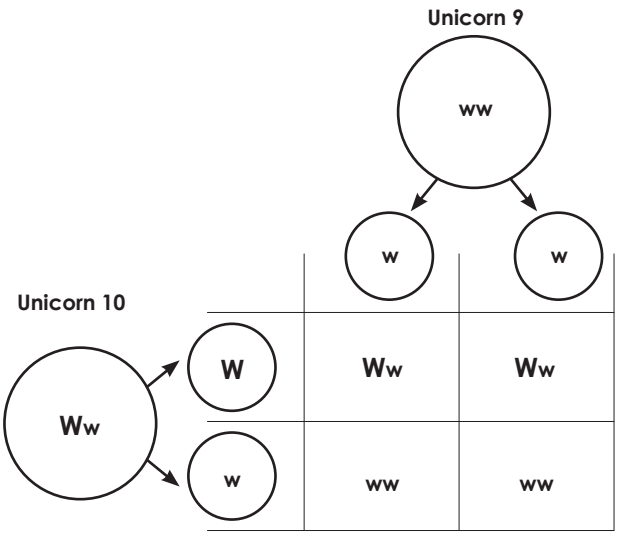
Unicorn 10 has wings so it must have at least one dominant allelle (W). The remaining allele can be deduced by examining the offspring of the cross between unicorn 9 and unicorn 10, particularly unicorn 17.

Unicorn 17 has no wings. The only possible genotype of this unicorn is homozygous recessive (ww). This means it must have gained one recessive allele from each of its parents - unicorns 9 and 10.

Also, unicorn 10 had a wingless parent (unicorn 2) who was homozygous recessive (ww) so must have passed on a recessive allele to unicorn 10.

Therefore, unicorn 10 is heterozygous (Ww).

(c)



(d) Fraction of offspring with wings = 1/2 (50%)

Fraction of offspring without wings = 1/2 (50%)

(e) Expected phenotypic ratio = 1 : 1

(f) Punnett squares predict probable offspring genotypes and, therefore the expected phenotypes, based on the gametes of the parents.

Pedigree charts give the observed (actual) phenotypes. Since each fertilisation is a random event, it is by chance whether the offspring of number 10 inherits the dominant W allele and therefore has wings or the recessive w allele and does not have wings.

In the pedigree chart 3 of the 4 offspring have wings but only 2 out of 4 would have been predicted from the Punnett square.

QUESTION THREE

Sexual reproduction is the production of new living organisms by combining genetic information from two individuals of different types (sexes). This is achieved by fusing two gametes.

Gametes are sex cells (sperm and egg) which are formed in the testes and ovaries. During gamete formation (meiosis), the homologous chromosomes are separated and the gamete will inherit one of each pair of chromosomes. Which chromosome is passed on is random due to the process of independent assortment.

During fertilisation, the gametes combine and the resulting offspring will have two alleles – they may inherit two alleles the same, homozygous, and show that characteristic or they may inherit one of each allele, heterozygous in which case they will show the dominant allele in their phenotype.

Genetic variation is a measure of the different alleles possible for each gene within a population. The advantage of variation to a population is that it may see some individuals survive if environment changes. Those with favourable alleles / traits / phenotypes will survive and be able to pass on their genetic material to offspring.

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