Grade 10 Optional Science Model Paper 2

ANSWER KEY

Full marks 75 · 2.25 hours

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

A practice paper by Science Playground, made to CDC's Specification Grid 2076, Science (Optional); not an official CDC or NEB paper.

Section A

16 × 1 = 16

a. A bivalent (tetrad) is a pair of homologous chromosomes joined together in synapsis during prophase I of meiosis; it has four chromatids.

Marking scheme

- A pair of homologous chromosomes paired in synapsis (four chromatids).

b. Transpiration is the loss of water as vapor from the aerial parts of a living plant, mostly through the stomata.

Marking scheme

- Loss of water as vapor from the aerial parts of a living plant.

c. A codon is a group of three bases on mRNA that stands for one amino acid (or start or stop).

Marking scheme

- Three mRNA bases that code for one amino acid.

d. Nitrogen fixation is the change of nitrogen gas (N_2) of the air into ammonia, ammonium or nitrate, which plants can use.

Marking scheme

- Changing N_2 into ammonia, ammonium or nitrate.

e. A plasmid is a small ring of DNA in a bacterium, separate from its chromosome; it is used as a vector in genetic engineering.

Marking scheme

- A small ring of DNA in a bacterium, apart from its chromosome.

f. The physical and chemical properties of the elements are periodic functions of their atomic numbers.

Marking scheme

- Properties of elements are periodic functions of their atomic numbers.

g. Molar volume is the volume of one mole of any gas at STP, 22.4 L.

Marking scheme

- Volume of 1 mole of a gas at STP (22.4 L).

h. Hydrolysis is a reaction of a substance with water in which the water splits, its H going to one part and its OH to the other.

Marking scheme

- Reaction of a substance with water, the water splitting into H and OH.

i. A heterocyclic compound is a ring compound in which the ring contains at least one atom other than carbon, such as nitrogen, oxygen or sulphur (for example, pyridine).

Marking scheme

- A ring compound with another atom (N, O, S) in the ring.

j. A flux is a substance added in metallurgy that combines with the gangue to form a liquid waste, slag (limestone in the blast furnace).

Marking scheme

- A substance added to join with the gangue to form slag.

k. Centripetal force is the force acting on a body moving in a circle, directed towards the center, that keeps it in the circle.

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Marking scheme

- Force towards the center that keeps a body moving in a circle.

l. A bimetallic strip is two different metals, such as brass and iron, joined face to face along their length, which bends when heated or cooled.

Marking scheme

- Two different metals joined face to face along their length.

m. It is the point on the principal axis where rays parallel to the axis meet after passing through a convex lens.

Marking scheme

- Point on the principal axis where parallel rays meet after refraction.

n. Doping is adding a few atoms per million of another element to a pure semiconductor to increase its conductivity.

Marking scheme

- Adding a tiny amount of another element to a semiconductor.

o. Lead dioxide (PbO_2).

Marking scheme

- Lead dioxide, PbO_2.

p. Half-life is the time taken for half of the atoms of a radioactive substance (the parent) to decay.

Marking scheme

- Time for half of a radioactive parent to decay.

Section B

13 × 2 = 26

2. Any two: **[2]**

Aerobic respiration	Anaerobic respiration
Needs oxygen.	Without oxygen.
In the cytoplasm and mitochondria.	In the cytoplasm only.
Food broken down completely.	Food broken down partly.
Gives CO_2 and water.	Gives ethanol and CO_2, or lactic acid.
Releases much energy (38 ATP).	Releases little energy (2 ATP).

Marking scheme

- One correct difference.
- A second correct difference.

3. Any two: **[2]**

DNA	RNA
Sugar is deoxyribose.	Sugar is ribose.
Bases A, G, C, T.	Bases A, G, C, U.
Double helix.	Single strand.
Mostly in the nucleus.	Mostly in the cytoplasm and ribosomes.
Stores genetic information.	Uses it to make proteins.

Marking scheme

- One correct difference.
- A second correct difference.

4. The root nodules of legumes hold *Rhizobium* bacteria, which fix nitrogen gas of the air into ammonia that the plants use to make proteins. When the roots and leftover plants decay, this nitrogen is added to the soil as ammonium and nitrate, so the next crop needs less fertilizer. **[2]**

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Marking scheme

- *Rhizobium* in the legumes' root nodules fixes N_2 of the air.
- The fixed nitrogen goes into the soil (as roots decay), so less fertilizer is needed.

5. A pyramid of biomass is a snapshot of one moment. Phytoplankton live only a few days; they divide fast and are eaten fast, so at any moment there are few of them. Over a year they produce far more food than their mass at one time, enough to feed a larger mass of zooplankton. **[2]**

Marking scheme

- The pyramid shows the mass at one moment only.
- Phytoplankton divide and are eaten fast, so over time they make far more than their standing mass.

6. Fluorine is very small, and its 2p subshell is crowded with electrons close together. An added electron is repelled strongly by them, so less energy is released than for chlorine, whose larger 3p subshell has more room. In a bond, fluorine's small size lets its nucleus pull a shared pair very strongly, so its electronegativity is the highest. **[2]**

Marking scheme

- Fluorine's small, crowded 2p repels the added electron, so less energy is released than for Cl.
- Chlorine's larger 3p has more room, so more energy is released.

7. Any two: **[2]**

Sigma (σ) bond	Pi (π) bond
Head-on (axial) overlap, on the axis between the nuclei.	Sideways overlap of parallel p orbitals, above and below the axis.
Larger overlap; stronger.	Smaller overlap; weaker.
Can exist alone.	Forms only after a σ bond.
Atoms can rotate about it.	No rotation.
Formed by s–s, s–p or p–p orbitals.	Formed only by p (or d) orbitals.

Marking scheme

- One correct difference.
- A second correct difference.

8. Any two: **[2]**

Addition	Substitution
Done by unsaturated compounds (alkenes, alkynes).	Done by saturated compounds (alkanes).
A multiple bond becomes single (or double).	The C–C bonds stay unchanged.
Gives one product.	Gives two products.
Example: $CH_2{=}CH_2 + Br_2 \rightarrow CH_2BrCH_2Br$.	Example: $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$.

Marking scheme

- One correct difference.
- A second correct difference.

9. C_5H_6 has a CH_2 group in the ring, which has no p orbital to share, so it breaks the ring of π electrons; it is not fully conjugated. In $C_5H_5^-$ that carbon carries a lone pair, so every ring atom takes part, and its π electrons are 2 + 2 + 2 = 6 = 4n + 2 (n = 1), so by Hückel's rule it is aromatic. **[2]**

Marking scheme

- C_5H_6's CH_2 breaks the conjugation, so it is not aromatic.
- $C_5H_5^-$ is fully conjugated with 6 (4n + 2) π electrons, so aromatic.

10. A vehicle needs a centripetal force towards the center to go round a bend. On a flat road only the friction of the tyres gives it, and that may not be enough, so the vehicle may skid outwards. On a **[2]**

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banked road the road's slanting push on the tyres has a part towards the center, which helps provide the centripetal force, so the bend can be taken safely.

Marking scheme

- Turning needs a centripetal force; friction alone may not be enough (skidding).
- The banked road's push has a part towards the center that supplies centripetal force.

11. Ice must first take in its latent heat of fusion (336,000 J for every kg) from the drink to melt, without warming up, and then the melted water takes in more heat as it warms. Water at 0 °C takes in only the second part, so ice takes much more heat from the drink. **[2]**

Marking scheme

- Ice takes in its latent heat of fusion from the drink while melting.
- Then the melted water absorbs more heat as it warms; water at 0 °C absorbs only this.

12. The molecules of a liquid have a range of speeds. The fastest ones at the surface escape as vapor, so the average kinetic energy of the molecules left behind falls. Temperature depends on the average kinetic energy, so the liquid cools. **[2]**

Marking scheme

- The fastest molecules escape from the surface.
- So the average kinetic energy of those left falls, and the temperature falls.

13. For a concave lens f is negative, and for a real object u is positive. So $\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$ is a negative number minus a positive number: always negative, so v is negative and the image is virtual (and upright, on the object's side). Since $\frac{1}{|v|} = \frac{1}{|f|} + \frac{1}{u}$ is larger than $\frac{1}{u}$, |v| is smaller than u, so $m = v/u$ is less than 1: the image is diminished. **[2]**

Marking scheme

- 1/v = 1/f − 1/u with f negative is always negative: v negative, virtual and upright.
- |v| < u, so the magnification is less than 1: diminished.

14. Ammonites were sea animals, so the rocks of Mustang were once mud on the floor of a sea, the Tethys Sea, about 150 million years ago. Finding them high in the Himalaya shows that these sea-floor rocks have since been lifted thousands of meters, as India pushed into Asia. **[2]**

Marking scheme

- Ammonites lived in the sea: the rocks were once the floor of the Tethys Sea.
- The rocks have since been lifted thousands of meters (as the Himalaya rose).

Section C

7 × 3 = 21

15. $V = \pi r^2 d = 3.14 \times 1^2 \times 70 \approx 220$ mm³ **[3]**

Rate $= \frac{220}{10} = 22$ mm³ per minute

A potometer measures the water taken up by the shoot, which is nearly equal to the water lost by transpiration.

Marking scheme

- V = πr²d ≈ 220 mm³.
- Rate ≈ 22 mm³ per minute.
- It measures water uptake, nearly equal to transpiration loss.

16. The places are on different chromosomes, so they are inherited independently, and the chances multiply. **[3]**

$\frac{1}{5} \times \frac{1}{12} \times \frac{1}{20} = \frac{1}{1{,}200}$: 1 in 1,200.

With the fourth place: $\frac{1}{1{,}200} \times \frac{1}{10} = \frac{1}{12{,}000}$: 1 in 12,000.

Marking scheme

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- Different chromosomes are inherited independently, so chances multiply.
- 1 in 1,200.
- 1 in 12,000 with the fourth place.

17. i. Group 2. The big jump comes after the second electron (1,451 → 7,733 kJ/mol): the third electron must come from the full inner shell. So X has two outer electrons (X is magnesium). **[3]**

ii. XCl_2 ($MgCl_2$).

Marking scheme

- Group 2.
- The huge jump after the second ionization shows two outer electrons.
- XCl_2.

18. Molar mass of Fe_2O_3 = 2 × 56 + 3 × 16 = 160; % Fe $= \frac{112}{160} \times 100\% = 70\%$ **[3]**

Hematite in the ore $= 80\% \times 2{,}000 = 1{,}600$ kg

Iron $= 70\% \times 1{,}600 = 1{,}120$ kg (1.12 tonnes)

Marking scheme

- % Fe = 112 ÷ 160 × 100 = 70%.
- Hematite = 1,600 kg.
- Iron = 1,120 kg.

19. $T = \frac{1}{f} = \frac{1}{2} = 0.5$ s **[3]**

$v = \frac{2\pi r}{T} = \frac{2 \times 3.14 \times 0.5}{0.5} = 6.28$ m/s

Tension $= F = \frac{mv^2}{r} = \frac{0.2 \times 6.28^2}{0.5} \approx 15.8$ N

Marking scheme

- T = 0.5 s.
- v = 6.28 m/s.
- F = $mv^2/r \approx 15.8$ N.

20. Total power $P = 3 \times 20 + 60 = 120$ W **[3]**

Current $I = \frac{P}{V} = \frac{120}{12} = 10$ A

Time $t = \frac{\text{capacity}}{I} = \frac{150}{10} = 15$ hours

Marking scheme

- Total power = 120 W.
- I = 10 A.
- t = 15 hours.

21. i. $\frac{1}{8} = \left(\frac{1}{2}\right)^3$, so 3 half-lives; $t = 3 \times 5{,}730 = 17{,}190$ years. **[3]**

ii. No. Carbon-14 can date only up to about 50,000 years; after that too little is left to measure.

Marking scheme

- 1/8 = (1/2)³: 3 half-lives.
- Age = 17,190 years.
- No: carbon dating works only to about 50,000 years.

Section D

3 × 4 = 12

22. i. 4 in each cell after meiosis I (each still double), and 4 in each gamete. **[4]**

ii. $2^n = 2^4 = 16$ kinds.

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iii. In pachytene of prophase I. It gives new mixtures of genes on each chromosome, so it adds variation.

iv. Non-disjunction gives gametes with 5 (n + 1) and 3 (n − 1) chromosomes.

Marking scheme

- 4 after meiosis I and 4 in each gamete.
- $2^4 = 16$ kinds of gamete.
- Pachytene; gives new combinations of genes (variation).
- Gametes with 5 and 3 chromosomes.

23. i. A reddish-brown coat of copper forms on the nail, and the blue solution slowly turns pale green. **[4]**

ii. $Fe + Cu^{2+} \rightarrow Fe^{2+} + Cu$; $Fe \rightarrow Fe^{2+} + 2e^-$ (oxidation); $Cu^{2+} + 2e^- \rightarrow Cu$ (reduction).

iii. Cu^{2+} (copper sulphate) is the oxidizing agent; Fe is the reducing agent.

iv. No. Copper is below iron in the reactivity series, so it cannot give electrons to Fe^{2+} and displace iron.

Marking scheme

- Reddish-brown copper on the nail; blue solution turns pale green.
- $Fe + Cu^{2+} \rightarrow Fe^{2+} + Cu$ with both half equations.
- Oxidizing agent Cu^{2+}; reducing agent Fe.
- No: copper is less reactive than iron.

24. i. $P = \frac{1}{f} = \frac{1}{0.10} = +10$ D. **[4]**

ii. $\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{10} - \frac{1}{15} = \frac{1}{30}$, so v = 30 cm, positive: a real image 30 cm on the far side of the lens.

iii. $m = \frac{v}{u} = \frac{30}{15} = 2$; height $= 2 \times 2 = 4$ cm, inverted (m positive: real and inverted).

iv. Closer than 10 cm (inside the focus); she sees a virtual, upright and magnified image on the object's side.

Marking scheme

- P = +10 D.
- v = 30 cm, real.
- m = 2, image 4 cm tall (inverted).
- Object inside F: virtual, upright, magnified image.

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