# Grade 10 Optional Science Model Paper 1

**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.** Crossing over is the exchange of matching pieces between non-sister chromatids of a pair of homologous chromosomes, in the pachytene stage of prophase I of meiosis.

**Marking scheme**

- Exchange of matching pieces between non-sister chromatids of homologous chromosomes.

**b.** Plasmolysis is the shrinking of a plant cell's protoplast away from its cell wall when the cell loses water by osmosis in a hypertonic solution.

**Marking scheme**

- The protoplast shrinking away from the cell wall as water leaves (in a hypertonic solution).

**c.** A test cross is a cross of an organism with a parent that is recessive for the genes being studied, to find out its genotype.

**Marking scheme**

- A cross with a parent recessive for the genes studied.

**d.** At each step of a food chain, only about 10% of the energy of one trophic level is passed on and stored in the next; about 90% is lost, mostly as heat.

**Marking scheme**

- Only about 10% of a level's energy passes to the next level (the rest lost, mostly as heat).

**e.** DNA fingerprinting is identifying a person, or how people are related, from the pattern of their DNA, mainly the lengths of repeated pieces at chosen places.

**Marking scheme**

- Identifying a person (or relatives) from their DNA pattern.

**f.** Electronegativity is the tendency of an atom in a molecule to attract the shared pair of electrons towards itself.

**Marking scheme**

- Tendency of a bonded atom to attract the shared pair of electrons to itself.

**g.** A coordinate covalent bond is a covalent bond in which both electrons of the shared pair come from the same atom.

**Marking scheme**

- A shared pair in which both electrons come from one atom.

**h.** Oxidation is the loss of electrons.

**Marking scheme**

- Loss of electrons.

**i.** A ring compound is aromatic if it is cyclic and planar, every ring atom takes part in the ring of π electrons, and it has $4n + 2$ π electrons (n = 0, 1, 2, …).

**Marking scheme**

- Cyclic, planar, fully conjugated ring with 4n + 2 π electrons is aromatic.

**j.** An ore is a mineral from which a metal can be extracted easily and profitably.

**Marking scheme**

- A mineral from which a metal can be extracted easily and profitably.



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**k.** A seconds pendulum is a simple pendulum whose time period is 2 seconds (its effective length is about 0.99 m on the Earth).

**Marking scheme**

- A pendulum with time period 2 s.

**l.** It is the heat needed to change 1 kg of a solid into liquid at its melting point, with no change in temperature.

**Marking scheme**

- Heat to change 1 kg of solid to liquid at its melting point without a change of temperature.

**m.** The power of a lens is the reciprocal of its focal length in meters, $P = 1/f$; its unit is the diopter (D).

**Marking scheme**

- Reciprocal of the focal length in meters (P = 1/f).

**n.** A shunt is a low resistance connected in parallel with a galvanometer to turn it into an ammeter.

**Marking scheme**

- A low resistance in parallel with a galvanometer.

**o.** A ferromagnetic substance is strongly attracted by a magnet and can be strongly magnetized, because its atomic magnets are lined up in domains; for example, iron (or cobalt, nickel).

**Marking scheme**

- Strongly attracted and strongly magnetized (domains), with an example such as iron.

**p.** An index fossil is the fossil of a living thing that was common, widespread and lived for only a short time, used to date and match rock layers, such as an ammonite.

**Marking scheme**

- A common, widespread, short-lived fossil used to date and match layers.

## Section B

**13 × 2 = 26**

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

| Mitosis | Meiosis |
|---|---|
| Takes place in somatic (body) cells. | Takes place in meiocytes (in testes, ovaries, anthers, ovules). |
| One division, two daughter cells. | Two divisions, four daughter cells. |
| Daughter cells are diploid (2n) and identical. | Daughter cells are haploid (n) and all different. |
| No synapsis or crossing over. | Synapsis and crossing over take place. |
| For growth, repair and asexual reproduction. | For gametes and spores, and variation. |

**Marking scheme**

- One correct difference.
- A second correct difference.

**3.** All the energy at a trophic level comes from the level below it, and at each step most of it is lost, mostly as heat in respiration. So a higher level always has less energy than the one below it. For the pyramid of energy to be inverted, a level would need more energy than it received, which would be energy made from nothing. **[2]**

**Marking scheme**

- Each level's energy comes only from the level below, and much is lost (as heat) at each step.
- So a higher level always has less energy; more would be energy from nothing.

**4.** Clones are made by mitosis alone, so every plant has the same genes. If one plant has no resistance to a disease, none of them has, so the disease can spread through the whole crop. For example, the Gros Michel banana was wiped out by Panama disease (or the Irish potato crop by late blight in the 1840s). **[2]**

**Marking scheme**

- All clones have the same genes, so if one is not resistant, none is.


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- A correct example: Gros Michel banana (Panama disease) or Irish potato (late blight).

**5.** DNA carries a negative charge because of the phosphate groups in its backbone, so it is pulled towards the positive electrode. The gel is a mesh that holds back big pieces more than small ones, so small pieces move faster and travel farther in the same time. **[2]**

**Marking scheme**

- DNA is negative (phosphate groups), so it moves to the positive electrode.
- The gel holds back large pieces more, so small pieces travel farther.

**6.** Magnesium is [Ne] $3s^2$ and aluminium [Ne] $3s^2\ 3p^1$. Aluminium's outermost electron is in a 3p orbital, which has higher energy than 3s and is shielded by the 3s electrons, so it is easier to remove. Magnesium must lose an electron from its full 3s subshell, which is more stable. **[2]**

**Marking scheme**

- Al's electron removed is in 3p, higher in energy (shielded by 3s), so it is easier to remove.
- Mg loses an electron from a full, stable 3s subshell.

**7.** Fe: [Ar] $4s^2\ 3d^6$ ($1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^6$). $Fe^{3+}$: [Ar] $3d^5$ (the two 4s electrons are lost first, then one 3d). **[2]**

$Fe^{3+}$ has a half-filled 3d subshell ($3d^5$), which is especially stable; $Fe^{2+}$ ($3d^6$) is not, so in air $Fe^{2+}$ is easily oxidized to $Fe^{3+}$.

**Marking scheme**

- Fe: [Ar] $4s^2\ 3d^6$ and $Fe^{3+}$: [Ar] $3d^5$.
- $Fe^{3+}$ has a half-filled ($d^5$) subshell, which is especially stable.

**8.** Ethene has a π bond between two carbons, which opens easily, so bromine adds across it (addition) and the color goes. In benzene the six π electrons are delocalized round the ring, which makes it unusually stable, so it resists addition; it reacts with bromine only by substitution, with a catalyst ($FeBr_3$), so bromine water keeps its color. **[2]**

**Marking scheme**

- Ethene's π bond opens and bromine adds to it, removing the color.
- Benzene's π electrons are delocalized and stable, so it resists addition (substitution only, with $FeBr_3$).

**9.** Nitric acid is an oxidizing agent, but alone it cannot keep gold in solution. In aqua regia (3 parts concentrated HCl to 1 part concentrated $HNO_3$) the nitric acid oxidizes the gold while the chloride ions from hydrochloric acid hold it as the $AuCl_4^-$ ion ($HAuCl_4$), so the gold keeps dissolving. **[2]**

**Marking scheme**

- $HNO_3$ oxidizes the gold (or: the two acids give nascent chlorine, which turns gold into $AuCl_3$).
- $Cl^-$ from HCl holds it as $AuCl_4^-$ ($HAuCl_4$), which $HNO_3$ alone can't do.

**10.** Velocity has both size and direction. In circular motion the speed stays the same but the direction of motion (along the tangent) changes at every point, so the velocity changes. A change of velocity is acceleration; it is directed towards the center. **[2]**

**Marking scheme**

- The direction of motion changes all the time, so the velocity changes.
- A change in velocity means acceleration (towards the center).

**11.** When steam touches the skin it first condenses to water at 100 °C, giving out its latent heat of vaporization (about 2,260,000 J for every kg), and then the water cools, giving out more heat. Boiling water gives only the second part, so steam gives the skin much more heat. **[2]**

**Marking scheme**

- Steam gives out its latent heat of vaporization as it condenses.
- This is in addition to the heat the water gives as it cools, so much more heat.

**12.** An object just beyond the objective's focus gives a real, inverted and magnified first image. That image, inside the eyepiece's focus, acts as an object for the eyepiece working as a magnifying glass, **[2]**


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which gives a virtual, further magnified final image where the eye can see it (usually at 25 cm).

**Marking scheme**

- Object just beyond $F_o$ gives a real, inverted, magnified first image.
- Inside $F_e$ the eyepiece acts as a magnifier, giving a virtual, more magnified final image.

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

| Real image | Virtual image |
|---|---|
| Rays really meet. | Rays only seem to come from it. |
| Can be caught on a screen. | Cannot be caught on a screen; seen only by looking into the lens. |
| Inverted (for a single lens). | Upright. |
| On the far side of a lens (v positive). | On the object's side (v negative). |

**Marking scheme**

- One correct difference.
- A second correct difference.

**14.** Carbon-14 has a half-life of only 5,730 years, so after about 50,000 years too little is left to measure. Dinosaurs died out over 66 million years ago, so their fossils have no measurable carbon-14 left (and are mostly turned to rock); they are dated from volcanic rocks around them by uranium–lead or potassium–argon. **[2]**

**Marking scheme**

- Carbon-14's half-life is short (5,730 years), so it can date only up to about 50,000 years.
- Dinosaur fossils are over 66 million years old, so none is left to measure.

## Section C

**7 × 3 = 21**

**15.** i. 46 chromosomes, 92 chromatids (DNA was copied in the S phase; each chromosome is double). **[3]**

ii. 23 chromosomes, 46 chromatids (the homologs separated; each chromosome still double).

iii. 23 chromosomes, 23 chromatids (the centromeres split at anaphase II).

**Marking scheme**

- Metaphase of mitosis: 46 chromosomes, 92 chromatids.
- After meiosis I: 23 chromosomes, 46 chromatids.
- After meiosis II: 23 chromosomes, 23 chromatids.

**16.** $\%\ \text{change} = \dfrac{\text{final} - \text{initial}}{\text{initial}} \times 100\%$ **[3]**

Distilled water: $\dfrac{2.80 - 2.50}{2.50} \times 100\% = +12\%$

Sugar solution: $\dfrac{2.04 - 2.40}{2.40} \times 100\% = -15\%$

Distilled water is hypotonic (water entered, mass rose); the sugar solution is hypertonic (water left, mass fell).

**Marking scheme**

- Distilled water: +12%.
- Sugar solution: −15%.
- Distilled water hypotonic, sugar solution hypertonic.

**17.** Molar mass of $CO_2$ = 12 + 2 × 16 = 44 g/mol **[3]**

$n = \dfrac{m}{M} = \dfrac{22}{44} = 0.5$ mol

Molecules $= n \times N_A = 0.5 \times 6.022 \times 10^{23} = 3.011 \times 10^{23}$

Volume at STP $= 0.5 \times 22.4 = 11.2$ L

**Marking scheme**

- n = 22 ÷ 44 = 0.5 mol.



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- Molecules = 3.011 × 10²³.
- Volume = 11.2 L at STP.

**18.** Molar mass of $H_2O_2$ = 34 g/mol, so $n = \dfrac{3.4}{34} = 0.1$ mol. **[3]**

From the equation, 2 mol $H_2O_2$ give 1 mol $O_2$, so 0.1 mol gives 0.05 mol $O_2$.

Mass $= 0.05 \times 32 = 1.6$ g; volume $= 0.05 \times 22.4 = 1.12$ L at STP.

**Marking scheme**

- 0.1 mol $H_2O_2$ gives 0.05 mol $O_2$ (2 : 1).
- Mass of $O_2$ = 1.6 g.
- Volume = 1.12 L at STP.

**19.** Melting: $Q_1 = mL = 0.2 \times 336{,}000 = 67{,}200$ J **[3]**

Warming: $Q_2 = ms\Delta T = 0.2 \times 4{,}200 \times 30 = 25{,}200$ J

Total $= 67{,}200 + 25{,}200 = 92{,}400$ J

**Marking scheme**

- Heat to melt = 67,200 J.
- Heat to warm the water = 25,200 J.
- Total = 92,400 J.

**20.** $I_g = 5\ \text{mA} = 0.005$ A; p.d. across the coil at full scale $= I_g G = 0.005 \times 40 = 0.2$ V **[3]**

$$S = \frac{I_g G}{I - I_g} = \frac{0.2}{2 - 0.005} = \frac{0.2}{1.995} \approx 0.10\ \Omega$$

It is connected in parallel with the galvanometer.

**Marking scheme**

- I_g G = 0.005 × 40 = 0.2 V.
- S = 0.2 ÷ 1.995 ≈ 0.10 Ω.
- Connected in parallel.

**21.** $\dfrac{N}{N_0} = \dfrac{1}{4} = \left(\dfrac{1}{2}\right)^2$, so $n = 2$ half-lives. **[3]**

$t = n \times 5{,}730 = 2 \times 5{,}730 = 11{,}460$ years

**Marking scheme**

- 1/4 = (1/2)².
- n = 2 half-lives.
- Age = 11,460 years.

## Section D

**3 × 4 = 12**

**22.** i. RrYy; round yellow. **[4]**

ii. RY, Ry, rY, ry (a quarter each).

iii. Round yellow : round green : wrinkled yellow : wrinkled green = 9 : 3 : 3 : 1.

iv. Wrinkled yellow $= \dfrac{3}{16} \times 1{,}600 = 300$. Of these, rrYY (1 in 3) breed true: about 100.

**Marking scheme**

- $F_1$: RrYy, round yellow.
- Gametes RY, Ry, rY, ry.
- $F_2$ ratio 9 : 3 : 3 : 1.
- 300 wrinkled yellow, of which about 100 (rrYY) breed true.

**23.** i. $CH_3CH_2CH_2CH_2CH_3$, pentane; $CH_3CH(CH_3)CH_2CH_3$, 2-methylbutane; $C(CH_3)_4$, 2,2-dimethylpropane. **[4]**

ii. 2,2-Dimethylpropane (9.5 °C). It is the most branched, so its molecule is rounder with less surface, its molecules attract each other least, and it boils lowest.



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iii. Chain isomerism (the skeleton of carbon atoms differs).

**Marking scheme**

- Pentane and 2-methylbutane with correct formulas.
- 2,2-dimethylpropane with correct formula.
- 2,2-dimethylpropane boils lowest: most branched, least surface, weakest attraction.
- Chain isomerism.

**24.** i. $l$ = thread + radius = 98.0 + 2.0 = 100.0 cm = 1.00 m. **[4]**

ii. $T = \frac{40.2}{20} = 2.01$ s; $g = \frac{4\pi^2 l}{T^2} = \frac{39.48 \times 1.00}{4.04} \approx 9.77$ m/s².

iii. The error in starting and stopping the watch is shared over 20 oscillations, so the error in one time period is 20 times smaller.

iv. Slow. On the mountain g is smaller, and $T = 2\pi\sqrt{l/g}$, so T becomes longer: each swing takes longer and the clock loses time.

**Marking scheme**

- l = 1.00 m (thread + radius).
- T = 2.01 s, g ≈ 9.77 m/s².
- The watch's error is spread over 20 oscillations (20 times smaller per period).
- Slow: g smaller, so T longer.


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