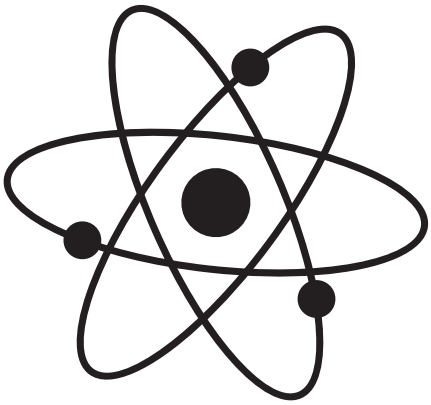
ASMOPSS THAILAND 2026

Asian Science & Mathematics Olympiad for Primary and Secondary Schools (Thailand)

Science Secondary G.12



Sunday, August 9, 2026

10:30 a.m. – 12:00 p.m. (90 minutes)

B

Instructions

1. This exam includes 40 questions, with 4 choices given (100 marks).
2. Use a 2B black pencil or darker one to fill in the circle.
3. Fill out your name, grade, school, test center, room, seat number, and identification number either in pen or in pencil.
4. If you want to change an answer that you have already marked, use a clean eraser to erase the incorrect answer and mark the new one.
5. It should be noted that figures in the exam are not drawn to scale.
6. Dictionaries, calculators, and electronic devices are not permitted in the test room.
7. Note taking can be done on the test paper only, with no extra sheet provided.
8. Do not write anything or make any symbols in the black barcode area along the edge of the paper except the answers on the answer sheet. Make sure the answersheet is not crumpled.
9. Submit the answer sheet to the proctor when the time is up.
10. Cheating in the exam may cause serious consequences including disqualification from receiving any award or joining the second round of the test held by ASMOPSS THAILAND.

Should any disagreement arise, the judgment of the panel is deemed final.

Announcement of the results via https://asmopssthailand.com on September 18, 2026

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Instructions :

1. Each question carries a different score, as indicated at the end of the question.
2. Students must select only the one best answer for each question.

1. Which of the following statements is incorrect regarding the sexual reproduction of typical flowering plants? (1.25 marks)

A. Imperfect flowers cannot undergo pollination.

B. Sexual reproduction in flowering plants requires meiosis to produce gametes.

C. Megaspores undergo meiosis to produce 8 nuclei, which develop into female gametophytes.

1. A and B
2. B and C
3. A and C
4. A, B and C

2. Which of the following statements correctly explains how C_4 plants are able to survive hot and arid conditions during the growing season? (1.25 marks)

1. When stomata close due to heat stress, RuBP carboxylase does not interact with oxygen, which accumulates in the leaf, allowing the plant to avoid photorespiration.
2. When stomata close due to heat stress, RuBP carboxylase binds to oxygen which accumulates inside the leaf, allowing the plant to avoid photorespiration.
3. When the stomata open due to heat stress, RuBP carboxylase does not bind to oxygen which accumulates inside the leaf, allowing photorespiration to be avoided.
4. When stomata close due to heat stress, RuBP carboxylase binds to oxygen which accumulates inside the leaf, allowing the plant to use oxygen for photosynthesis,

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3. How do digestive systems of humans and earthworms compare? (1.25 marks)

1. They differ in that digestion is an extracellular process in humans and occurs with a complete digestive track. On the other hand, earthworm digestion is an intracellular process and occurs within an incomplete digestive tract.

2. They differ in that earthworms have a sac-like body plan, while humans have a tube-within-a-tube body plan.

3. They are similar in that both organisms use extracellular digestion that occurs within a complete digestive tract.

4. They are similar in that in both organisms use intracellular digestion within the digestive tract, which is complete in humans but incomplete in earthworms.

4. Muscular dystrophy affects the functioning of skeletal muscles. In individuals affected by the condition, the contraction of the diaphragm and intercostal muscles may be impaired. How do these physiological changes impact the gas exchange capacity of patients?
(1.25 marks)

1. It directly impairs the capacity for gas exchange within the nasal muscles and along the respiratory tract to the lungs, causing the patients to not be able to breathe independently for short periods, which can be fatal.

2. It reduces the air movement into and out of the lungs, decreasing the rate of gas exchange.

3. It leads to increased mucus accumulation within the respiratory tract as the airway muscles become degenerated, decreasing gas exchange.

4. It lowers the surface area for gas exchange within the respiratory system due to the destruction of airway muscles, leading to a systematic decline in gas exchange.

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5. If a neuron receives both excitatory and inhibitory signals at the same time, will an action potential still be generated? (1.25 marks)

1. No, because inhibitory signals cancel out the excitatory signals, preventing any action potential from forming.

2. Yes, but the action potential will be much smaller than if only excitatory signals were received by neurons.

3. Yes, if more excitatory than inhibitory signals are received, then an action potential can be generated.

4. Yes, because excitatory signals will always stimulate an action potential, regardless of inhibitory signals.

6. In the laboratory, a student produced hydrogen gas (H_2) from a reaction between a metal and an acid. Carbon dioxide gas (CO_2) was also generated from impurities in the system, resulting in a gas mixture of H_2 and CO_2.

This gas mixture is collected over water in a fixed-volume container of 2.00 L at a temperature of 298 K, and the total pressure measured is 1.00 atm. The vapor pressure of water at 298 K is given as 0.03 atm.

From further experimentation, it was found that when the gas mixture was passed through a CO_2 absorbent such as NaOH, the gas volume decreased by 25% under the same conditions.

The table shows the gas volumes before and after the absorption of carbon dioxide

Experiment	Volume (L)
Before absorption	2.00
After absorption	1.50

Given: R = 0.082 L•atm•mol^{-1}•K^{-1}

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Consider the following statements:

A. The total partial pressure of the gases (excluding water vapor) is equal to 0.97 atm.

B. Carbon dioxide (CO_2) accounts for 25% by volume.

C. The total number of moles of the gases (excluding water vapor) is approximately 0.079 mol.

D. The number of moles of H_2 is greater than that of CO_2.

Which of the following statements are correct? (1.25 marks)

1. A, B, and C
2. A, B, and D
3. B, C, and D
4. All of the above

7. Consider the following statements:

A. A solution containing HCl and NaCl can act as a buffer.

B. A buffer can resist changes in pH when a “small amount” of acid or base is added.

C. A solution containing CH_3COOH and CH_3COONa can act as a buffer.

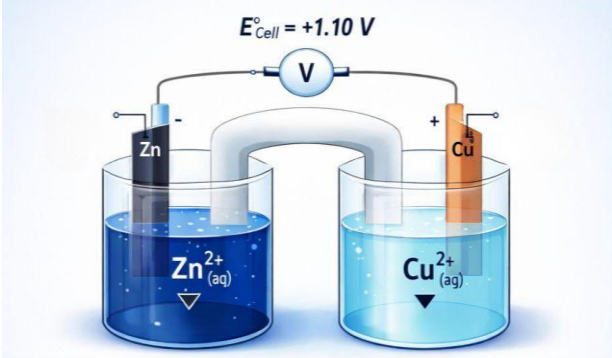
D. If the concentrations of the acid and the base in a buffer are equal, the pH will be equal to the pKa.

Which of the following is the correct answer? (1.25 marks)

1. 1 statement is correct, 3 statements are incorrect
2. 2 statements are correct, 2 statements are incorrect
3. 3 statements are correct, 1 statement is incorrect
4. All statements are correct

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8. Consider the following image and statements:



A. Zinc (Zn) is the anode in this cell.

B. Electrons flow from Zn to Cu.

C. A positive E°_{cell} indicates that the reaction is spontaneous.

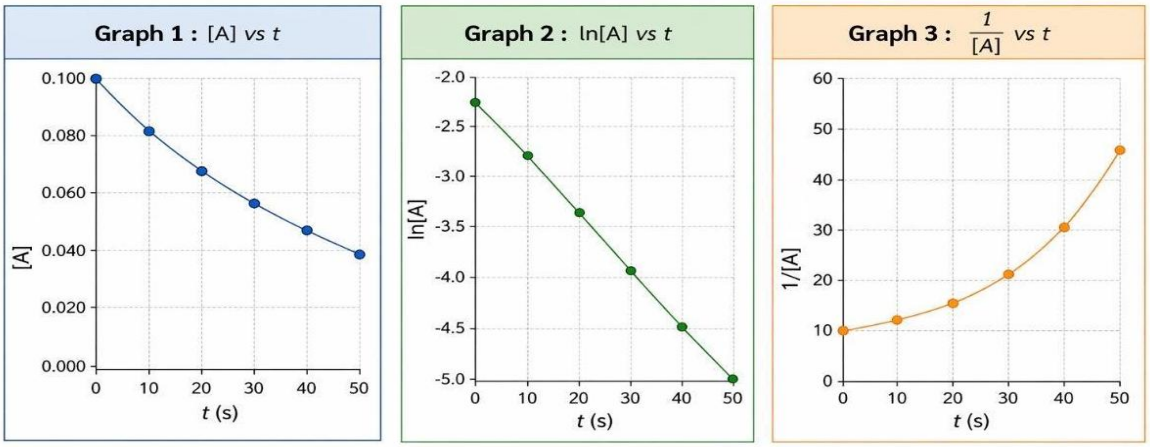
D. Cu is reduced at the cathode.

Which of the following is the correct answer? (1.25 marks)

1. A and B
2. A, B, and D
3. B, C, and D
4. All of the above

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9. A student studied the reaction of substance A and plotted three graphs that show the relationship between the concentration of substance A and time, as shown in the graphs below.



Which graph is a straight line that best corresponds to this reaction, and what is the order of this reaction? (1.25 marks)

1. Graph 1 and it is a zero-order reaction
2. Graph 2 and it is a first-order reaction
3. Graph 3 and it is a second-order reaction
4. Cannot be determined

10. How does the discovery of the cosmic microwave background, which can be detected from all directions at all times (both day and night), support the Big Bang theory?
(1.25 marks)

1. The cosmic microwave background is generated from the radiation emitted by the very first stars.
2. The cosmic microwave background has a uniform density in all directions.
3. The cosmic microwave background is caused by the Milky Way and Andromeda galaxies moving towards each other.
4. The cosmic microwave background resulted from the formation of hydrogen atoms and has wavelengths in the microwave range due to the expansion of the universe.

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11. Protostars with a mass greater than 25 times that of the Sun will evolve into a blue giant that possesses a larger amount of hydrogen fuel than low-mass stars like the Sun. However, why do high-mass stars have a shorter lifespan and evolutionary sequence than low-mass stars? (1.25 marks)

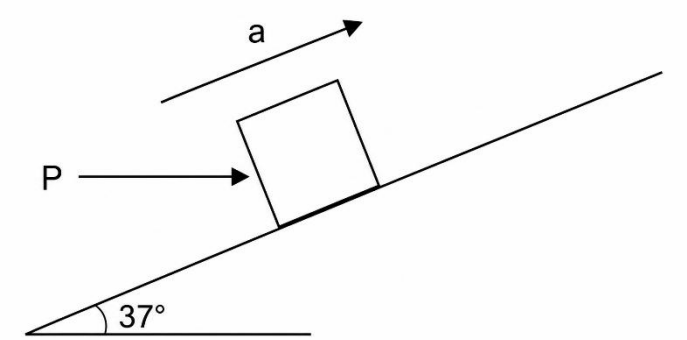
1. Low-mass stars can use helium as fuel instead of hydrogen.
2. Massive stars completely consume their energy to generate magnetic fields during the early stages of their evolution.
3. Massive stars have higher gravity and temperatures, resulting in a very high rate of thermonuclear reactions.
4. Massive stars have a lower density, which results in a lower rate of thermonuclear reactions at the core.

12. Sunspots are regions that are darker and cooler compared to their surroundings. This phenomenon appears in the Sun's photosphere. Which of the following is the main factor that causes sunspots to have a lower temperature than their surroundings, and why? (1.25 marks)

1. Solar flares because a large number of high-energy particles are released.
2. The Sun's magnetic field, because the high magnetic field intensity blocks convection.
3. Coronal mass ejections, because heat is absorbed to be used as fuel at the Sun's core.
4. Prominence, because the energy transfer process changes from convection to radiation.

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13. A horizontal force of P = 50.0 N is applied to a 2.0 kg block, pushing it up an inclined plane at a constant acceleration, as shown in the figure.



The coefficient of kinetic friction between the block and the inclined plane is 0.5. Find the magnitude of the acceleration. (Assume g = 10 m/s^2, sin37° = 0.6, and cos 37° = 0.8)
(1.25 marks)

1. 1.5 m/s^2
2. 2.0 m/s^2
3. 2.5 m/s^2
4. 3.0 m/s^2

14. Consider the following table:

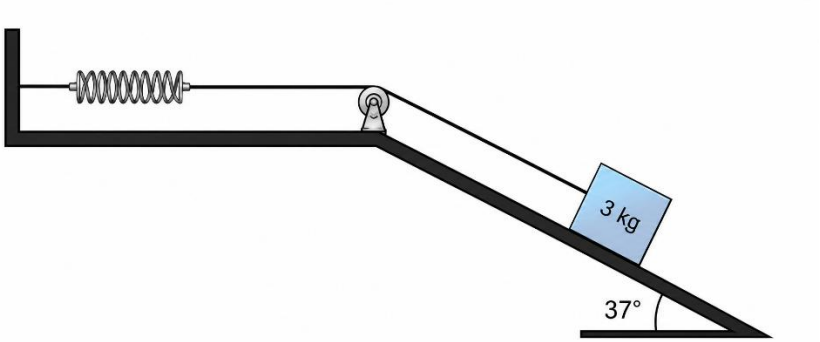
Wire number	Material	Young's modulus (GPa)	Cross-sectional area (m²)
1	Steel	200.0	10.0 x 10^{-6}
2	Aluminum	70.0	40.0 x 10^{-6}

A student wants to use one of these circular wires to make a vertical hanger for a 2.50 kg hammer. The upper end of the wire is fixed to a wall. Once the hammer is hung, the wire must stretch by no more than 5.0 μm. If the original length of the wire is 50.0 cm, which wire should the student use? (Assume g = 10 m/s^2). (1.25 marks)

1. Wire number 1
2. Wire number 2
3. Both wires can be used
4. Neither wire can be used

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15. A 3.0 kg block is connected to a light string that runs over a frictionless pulley and connects to a spring with a spring constant of 80 N/m, as shown in the figure.
The block is initially held at rest with the spring unstretched. What is the speed of the block after it has slid 0.25 m down the incline, assuming both the inclined and horizontal surfaces are completely frictionless? (Assume g = 10 m/s^2, sin37° = 0.6, and cos 37° = 0.8
(2.5 marks)



1. 0.8 m/s
2. 1.0 m/s
3. 1.2 m/s
4. 1.4 m/s

16. An object moves with simple harmonic motion. Its velocity is $v(t) = 1.00\sin(50t + \frac{\pi}{2})$ m/s. What is the displacement of the object when its acceleration is -25.0 m/s^2? (2.5 marks)

1. 1.00 cm
2. -1.00 cm
3. 1.73 cm
4. -1.73 cm

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17. A patient who has recently undergone surgery to remove tumors from his thyroid gland suddenly begins to tremble violently from head to toe because his nerves have become overstimulated. Which of the following best explains the cause of this condition? (2.5 marks)

1. Too much thyroid tissue was removed, and without oxytocin, blood calcium levels fell too low.
2. The parathyroid glands were removed, and without parathyroid hormone (PTH), blood calcium levels rose too high.
3. The parathyroid glands were removed, and without parathyroid hormone (PTH), blood calcium levels fell too low.
4. Too much thyroid tissue was removed, and without calcitonin, blood calcium levels fell too low.

18. A large number of hormones and chemicals are involved in the ovarian cycle. In particular, the first half of ovarian function is crucial for the development of the female reproductive system. Which of the following statements is correct? (2.5 marks)

1. Both estrogen and progesterone levels rise significantly to prepare the body for ovulation and sexual reproduction.
2. Luteinizing hormone (LH) promotes the growth of the corpus luteum, which plays a role in the secretion of estrogen and progesterone.
3. The corpus luteum reaches its maximum size, during which it decreases estrogen production while triggering the secretion of progesterone.
4. Follicle-stimulating hormone (FSH) promotes the development of ovarian follicles, which play a role in estrogen secretion.

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19. During a field trip, an instructor touched a moth resting on a tree trunk. The moth raised its forewings to reveal large eyespots on its hindwings. The instructor asked the class why the moth lifted its wings. One student answered that sensory receptors had fired and triggered a neuronal reflex culminating in the contraction of certain muscles. A second student responded that the behavior might frighten predators. Which statement best describes these explanations? (2.5 marks)

1. The first student's explanation is correct because it refers to the nervous system, but the second student's explanation is incorrect because it is merely a hypothesis that may or may not be correct.

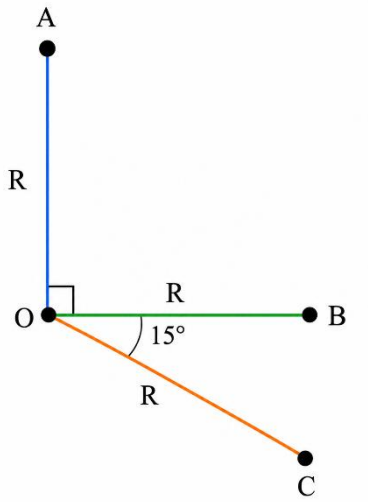
2. The first explanation refers to proximate causation, whereas the second refers to ultimate causation.

3. The first explanation is biological, whereas the second is philosophical.

4. The first student's explanation can be used to test a scientific hypothesis, while the second student's explanation cannot because it is merely a guess at animal behavior.

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20. Point charges -q, (+q), +q, and -$\sqrt{2}$ q are placed at points O, A, B, and C, respectively. Point O is located a distance (R) away from points A, B, and C, as shown in the diagram.



Find the magnitude of the net force acting on the charge at point O. Given that sin 15° = 0.26, cos 15° = 0.97 and Coulomb's constant is (k_E). (2.5 marks)

1. $\frac{q^2 k_E}{R^2}$ N

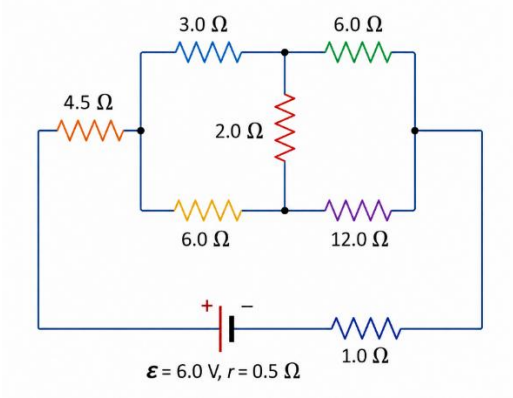
2. $\frac{\sqrt{2} q^2 k_E}{R^2}$ N

3. $\frac{0.57 q^2 k_E}{R^2}$ N

4. $\frac{2.35 q^2 k_E}{R^2}$ N

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21. From the circuit shown in the figure,



find the current through the 3.0 **Ω** (2.5 marks)

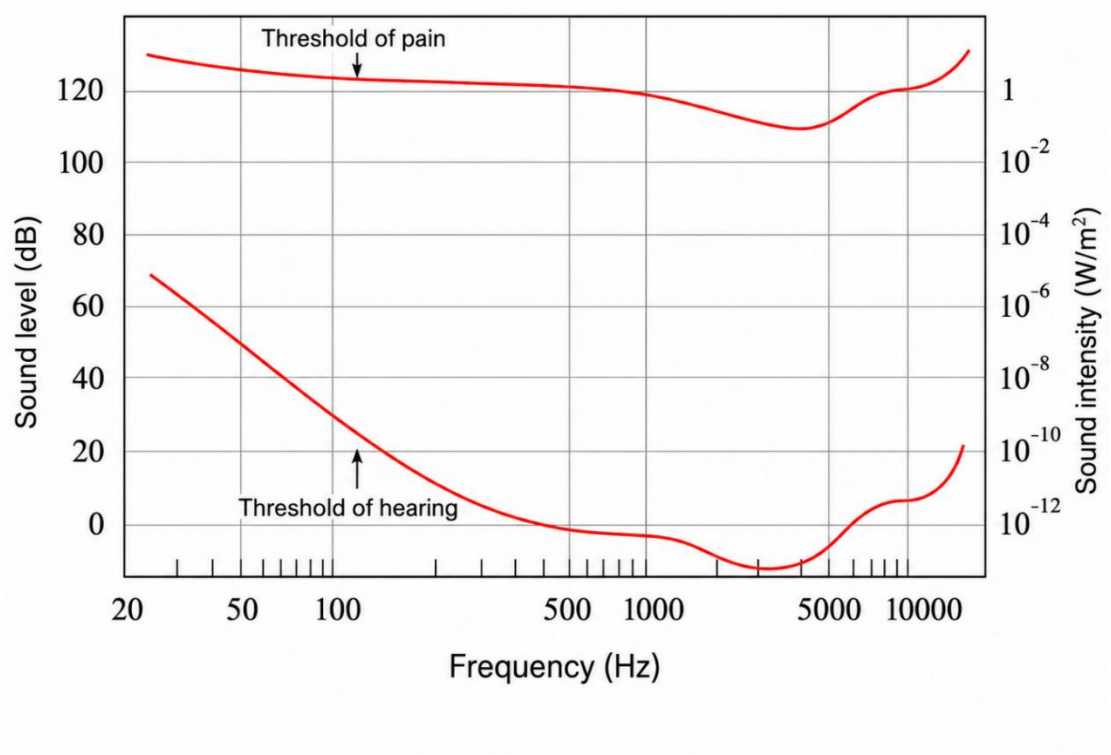
1. 0.33 A
2. 0.50 A
3. 0.67 A
4. 0.75 A

22. A 6-slot stroboscope is used to measure the vibration frequency of a 20 g mass hanging from a vertical spring. The mass appears completely stationary when the stroboscope spins at 300 revolutions per minute. What is the spring constant of this spring? (2.5 marks)

1. $50\pi^2$ N/m
2. $72\pi^2$ N/m
3. $5.0\text{x}10^2\pi^2$ N/m
4. $7.2\text{x}10^2\pi^2$ N/m

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23. A student uses a sound generator with a frequency of 1000 Hz. At a distance of 1.5 m from the generator, the measured sound level is 60 dB. If the student uses four identical sound generators operating at the same time, what is the approximate increase in sound level at a distance of 1.0 m from the four generators? (2.5 marks)
(Given: log 2 = 0.3010, log 3 = 0.4771, and the relationship between audible sound level and frequency is provided in the graph below.)



1. 3.0 dB
2. 4.7 dB
3. 7.8 dB
4. 9.5 dB

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24. A 2.0 kg box moving at 3.0 m/s on a smooth horizontal surface collides with a system of two springs. One spring has a spring constant of 300 N/m and the other has a spring constant of 600 N/m. The two springs have the same natural length and are connected in series. The end struck by the box can move freely, while the other end is fixed to a wall. When the spring system is compressed to its maximum, how much is the 300 N/m spring compressed? (2.5 marks)

1. 0.05 m
2. 0.10 m
3. 0.15 m
4. 0.20 m

25. A water rocket is launched from the ground with a constant acceleration of 20.0 m/s^2 at an angle of 37° above the horizontal. After 1.0 s, the water in the bottle is completely used up, so the rocket continues moving without any thrust. How far from the launch point will the rocket land? Assume that (g = 10 m/s^2, sin37° = 0.6 and cos 37° = 0.8) (2.5 marks)

1. 26 m
2. 53 m
3. 72 m
4. 87 m

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26. A student collected a "mystery rock" from a natural source and suspected that it contained calcium carbonate ($CaCO_3$) as a component. The student then crushed the rock and weighed out 12.5 g. The sample was then reacted with 150 ml of 1.00 mol/l hydrochloric acid (HCl) solution. The chemical reaction is shown below:

$$CaCO_3\ (s) + 2\ HCl\ (aq) \longrightarrow CaCl_2\ (aq) + CO_2\ (g) + H_2O\ (l)$$

After the reaction was completed, the student was able to actually collect 2.24 L of CO_2 gas at STP. Further analysis shows that the rock sample contains some non-reactive impurities.

Based on the information above, consider the following statements:

A. $CaCO_3$ is the limiting reactant in the reaction.

B. The actual number of moles of CO_2 is equal to 0.100 mol.

C. If the $CaCO_3$ were completely pure, more CO_2 would be produced than was actually measured.

D. The rock sample contains approximately 80% $CaCO_3$ by mass.

Which of the following statements are correct? (2.5 marks)

1. A and B
2. B and C
3. B, C, and D
4. None of the above

27. The corona is the Sun's outer atmosphere, which has a low density and extends very far out. This atmospheric layer has a high temperature of about 1–2 million Kelvin. Observers on Earth can see the corona during a total solar eclipse. To study and photograph the corona, which wavelength range of telescope should be used and why? (5 marks)

1. Optical telescope, because it can be seen with the naked eye.
2. Ultraviolet telescope, because it is the radiation emitted most by the Sun.
3. X-ray telescope, because the extremely high temperature causes it to emit short-wavelength and high-energy radiation.
4. Radio telescope, because the corona has a low density and low energy.

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28. A chain of volcanic islands is aligned in a straight line from southeast to northwest in the middle of the Pacific Ocean. Island A has a basaltic rock age of 1 million years, while Island B has a basalt rock age of 5 million years. Island C is located 250 kilometers northwest of Island A, has a basalt rock basaltic rock age of 11 million years. All three volcanic islands were formed by the same hotspot. Based on the information, at what speed and in which direction is the tectonic plate moving? (5 marks)

1. 2.5 meters per year, moving towards the southeast
2. 5 meters per year, moving towards the southeast
3. 2.5 centimeters per year, moving towards the northwest
4. 5 centimeters per year, moving towards the northwest

29. The Coriolis force is caused by the Earth's rotation on its axis, which deflects the direction of air movement and the flow of ocean surface currents from their original path. The factors affecting the magnitude of the Coriolis force are the mass of the moving object, the angular velocity, and the object velocity. Based on this information, in which region of the Earth does the Coriolis force have no effect on air movement and the direction of surface ocean currents? (5 marks)

1. The equator
2. The North Pole and South Pole
3. Latitude 30 degrees North latitude and 30 degrees South
4. Latitude 60 degrees North latitude and 60 degrees South

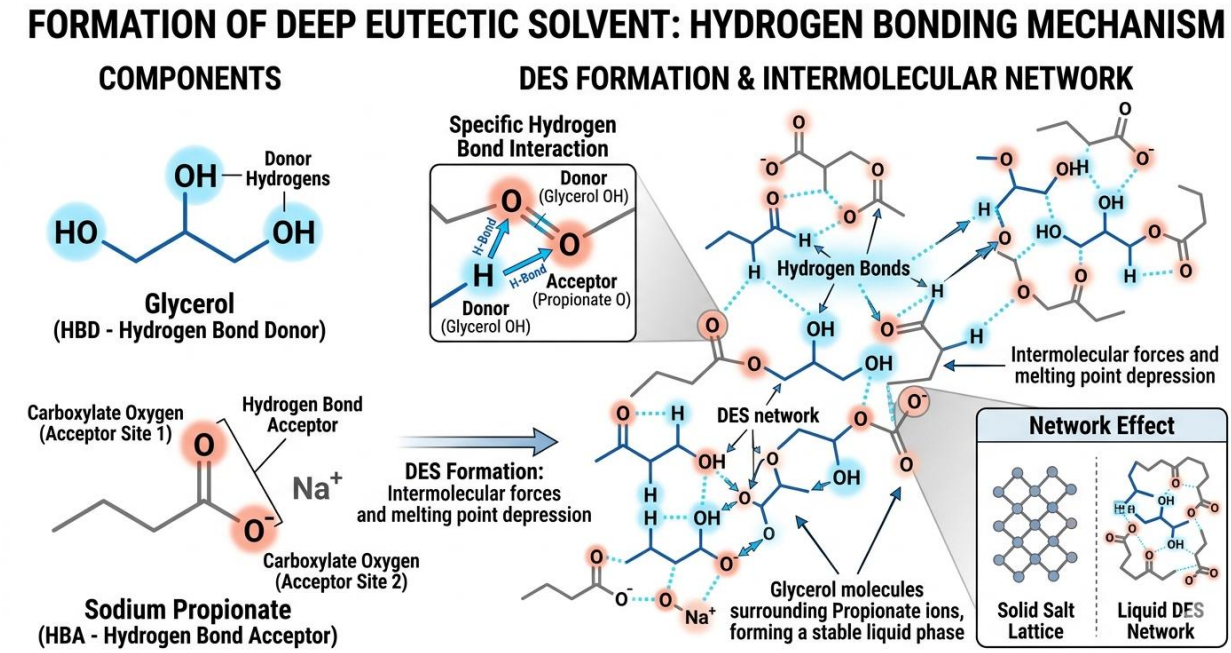
30. A coastal city has an air temperature of 30°C. If a sea breeze pushes a parcel of air from this city over a 3,000-meter-high mountain range located behind it, what will be the temperature difference (in degrees Celsius) between the air has crossed over the mountain range down to the plains (which are at sea levels) and the original air temperature at the coastal city? (**Given**: Dew point temperature = 20°C, Dry Adiabatic Lapse Rate = 10°C/km, and Moist Adiabatic Lapse Rate = 5°C/km) (5 marks)

1. 5 °C
2. 10 °C
3. 15 °C
4. 20 °C

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Use the information provided to answer Questions 31–32.

Deep Eutectic Solvents (DES) are a special type of solution formed by mixing two or more components, typically consisting of a hydrogen bond donor (HBD) and a hydrogen bond acceptor (HBA). When combined, strong intermolecular interactions—particularly hydrogen bonding—are formed in large numbers. These interactions disrupt the original crystal structures of the components, resulting in a significant decrease in the melting point of the system compared to the individual starting substances. The mechanism of formation of this type of solution is illustrated in the figure below.



31. Consider the following statements. Which of the following is incorrect? (1.25 marks)

1. Hydrogen bonding in a DES system arises from the attraction between the dipole of an O–H bond and the lone pair electrons on the oxygen atom in a carboxylate group.

2. DES has stronger intermolecular forces than the starting substances, which leads to a decrease in melting point.

3. Glycerol is a polar molecule, so it can exhibit dipole–dipole interactions and hydrogen bonding.

4. Sodium propionate can act as a hydrogen bond acceptor because its negative charge increases the electron density on the oxygen atom.

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32. Consider the following statements. Which of the following is incorrect? (1.25 marks)

A. Glycerol is classified as a polyhydric alcohol because it contains more than one –OH group.

B. Sodium propionate is a salt of a carboxylic acid and can be converted back to the acid when it reacts with a strong acid.

C. Glycerol is a nonpolar substance because its structure is symmetrical.

D. The –OH groups in glycerol can undergo esterification with a carboxylic acid at only one position.

1. B and C
2. C and D
3. B, C, and D
4. None of the statements are incorrect

33. Nowadays, effervescent tablets have become increasingly popular in health and pharmaceutical products such as vitamin supplements, electrolytes, and pain relievers. This is because they dissolve quickly in water, have a pleasant taste, and allow the body to absorb active ingredients efficiently.

Consumer trends show that more than 50% of users prefer effervescent tablets over conventional tablets due to their convenience and rapid effect.

When an effervescent tablet is added to water, a reaction occurs between an organic acid and sodium bicarbonate, producing carbon dioxide (CO_2) gas and forming bubbles, as shown in the equation:

$$\text{Acid} + NaHCO_3 \longrightarrow CO_2\,(g) + H_2O + \text{salt}$$

This reaction forms the basis for designing effervescent products in industry, where manufacturers must control the “rate of reaction” so that the tablet dissolves quickly, but not so fast that excessive foaming causes overflow.

Factors affecting the reaction rate include water temperature, tablet size (surface area), and stirring, all of which influence the frequency and energy of collisions between reactant particles.

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A student conducts an experiment to study factors affecting the reaction rate by measuring the volume of CO_2 gas produced (mL) over time (s), as shown in the table:

Time (s)	Volume of CO_2 gas produced (mL)		
	Experiment 1	Experiment 2	Experiment 3
10	15	30	25
20	25	50	40
30	30	60	50
40	30	60	50

Experimental conditions:

Experiment 1: Cold water + whole tablet

Experiment 2: Hot water + whole tablet

Experiment 3: Cold water + crushed tablet

Based on the experiment, the student studies the “rate of reaction” using the volume of CO_2 produced.

Consider the following statements:

A. The average rate of reaction during 0–20 s in Experiment 2 is greater than that in Experiment 3 and approximately twice that of Experiment 1.

B. The fact that the CO_2 volume graphs for all experiments reach the same plateau indicates that the number of moles of the limiting reactant is the same.

C. Increasing temperature increases the reaction rate because the number of collisions with energy greater than E_a increases, according to Collision Theory.

D. Crushing the tablet increases the reaction rate and also increases the final amount of CO_2 produced.

Which of the following is incorrect? (2.5 marks)

1. B and D
2. A, B, and D
3. B, C, and D
4. None of the statements are incorrect

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34. The study of seismic waves traveling through the Earth's internal structure shows that the velocity of the waves increases with depth from the Earth's surface, indicating that temperature, pressure, and density increase with depth. Seismic wave data can also reveal the physical state of the Earth's structures: the outer core is liquid, and the inner core is solid. Based on this information, why is the inner core solid? (2.5 marks)

1. The inner core has a different chemical composition than the outer core.
2. The inner core is composed of iron, which is less dense than the outer core.
3. The inner core is surrounded by the Earth's magnetic field, which is generated by the outer core.
4. The inner core is under immense pressure, which causes the melting point of the matter to be higher than that in the outer core.

35. Consider four hypothetical elements, A, B, C, and D which have the following electron configurations:

A : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

B : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

C : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$

D : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

Consider the following statements:

a) Element B has a higher ionization energy than element A because it experiences a stronger nuclear attraction.

b) Element C has the largest atomic radius in this group because it has a higher principal energy level.

c) Element D has the lowest tendency to undergo chemical reactions because it has a complete set of valence electrons.

d) Element A has a lower ionization energy than element B but higher than element C.

Which of the following is correct? (2.5 marks)

1. a and b
2. a, b, and c
3. b, c, and d
4. All of the above

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36. On 24 June 2026, two massive earthquakes struck northwestern and central Venezuela. The first earthquake, a magnitude of M_w 7.2, was classified as a foreshock. It was followed 39 seconds later by a powerful M_w 7.5 mainshock. The two earthquakes caused widespread destruction across the country, particularly in La Guaira and Caracas.

The disaster claimed over 1,700 lives, injured more than 5,000 people, and left over 46,600 missing. At the epicenter, the Caribbean plate moves eastward relative to the South America plate at a rate of roughly 20 mm/yr. The earthquake's location, shallow depth, and right-lateral strike-slip mechanism are consistent with rupture primarily along this plate boundary system. Based on the information provided, is there a possibility of another major earthquake occurring in the region? (2.5 marks)

1. No further major earthquakes will occur because all the energy has been released.
2. Once an earthquake strikes, the fault line permanently locks, meaning another earthquake can no longer occur in that same area.
3. There is a possibility of future major earthquakes because the tectonic plates continue to move, causing stress to steadily build up along the fault lines.
4. Earthquakes occur when one tectonic plate subducts beneath another around the Ring of Fire, as subduction is the primary driving mechanism for seismic activity in this region.

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37. An island arc is located near the Ring of Fire. The volcanoes on these islands are large stratovolcanoes (composite cones). The underground magma has high viscosity and high silica content. If a volcano in this island arc erupts, how will the global climate change over the next five years, and what is the cause of this climate change? (5 marks)

1. There is no climate change because the water vapor from volcanic eruptions cannot remain in the atmosphere for long.

2. The average global temperature rises, because volcanoes release a massive amount of greenhouse gases into the atmosphere.

3. The average global air temperature has decreased, because aerosols and volcanic ash suspended in the atmosphere block sunlight.

4. The average global air temperature rises, because the ocean water becomes more acidic due to a large amount of lava flowing into the oceans.

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38. A rise in the atmospheric carbon dioxide (CO_2) in the atmosphere is one of the major contributors to global climate change. To reduce greenhouse gas emissions from large industrial sources, many power plants and manufacturing facilities have adopted Carbon Capture and Storage (CCS) technology. In this process, CO_2 is separated from flue gas before being released into the atmosphere. The captured CO_2 may then be compressed and transported for underground storage or utilized in various industrial applications. In addition to reducing greenhouse gas emissions, industries that achieve verified emission reductions may also receive carbon credits under certain environmental regulations.

One of the most widely used CO_2 capture methods employs an aqueous amine solution as the absorbent. In the absorber column, flue gas flows upward while the amine solution flows downward, allowing CO_2 to dissolve into the liquid phase.

The dissolution of CO_2 can be represented by the following equilibrium:

$$CO_2\,(g) \rightleftharpoons CO_2\,(aq)$$

Unlike pure water, an aqueous amine solution can react reversibly with dissolved CO_2 to form more stable chemical species.

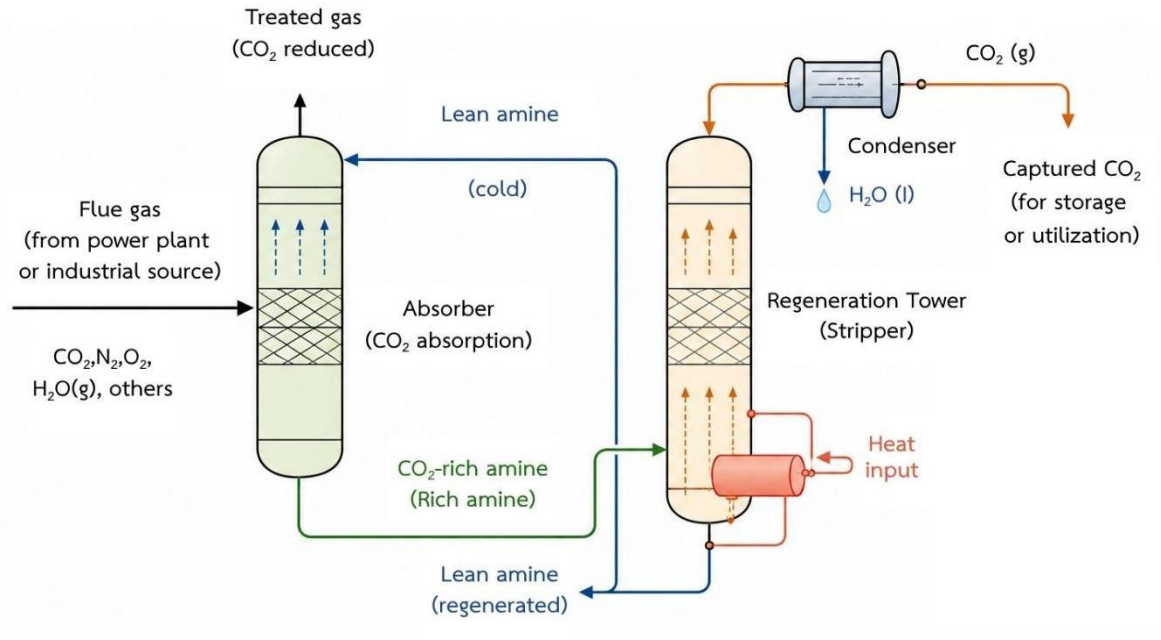
$$CO_2\,(aq) + RNH_2 \rightleftharpoons RNHCOO^- + H^+$$

Here, RNH_2 represents a primary amine molecule and $RNHCOO^-$ is a carbamate ion.

After absorption, the CO_2-rich solution is transferred to a regeneration tower (stripper), where thermal energy is supplied to release CO_2 from the absorbent. The regenerated amine solution is then recycled back to the absorber for repeated use.

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The overall process of CO_2 capture and regeneration in an amine-based system is illustrated in the figure below.



Consider the following statements. Which statement is incorrect? (5 marks)

1. Increasing the pressure of flue gas entering the absorber increases the amount of CO_2 dissolved in the liquid phase, because higher gas pressure promotes the transfer of CO_2 from the gas phase to the liquid phase.

2. In the regeneration tower, the application of heat causes CO_2 to be released from the amine solution because higher temperature favors the decomposition of carbamate species.

3. Carbon capture and carbon credits are different systems; carbon capture refers to a chemical or engineering process, while carbon credits represent a regulatory policy for accounting emission reductions.

4. If the flow rate of flue gas is increased while keeping all other conditions constant, the equilibrium CO_2 concentration in the absorber must increase proportionally.

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39. Two identical trucks, each weighing 5,000 kg, have a maximum cargo capacity of 10,000 kg. The first truck is stationary with a 6,000 kg load, when the second truck rear-ends it at 90 km/h. The impact causes them to lock together and move forward at 54 km/h. Acting as an expert witness, you are asked to determine if the second truck was overloaded. What do you conclude in your report? (5 marks)

1. The second truck was within its legal weight limit.
2. The second truck was illegally overloaded by 1,500 kg.
3. The second truck was illegally overloaded by 2,500 kg.
4. More information is required.

40. The increasing use of electric vehicles has created large quantities of spent lithium-ion batteries containing valuable metals such as lithium, cobalt, nickel, and manganese. These metals can be recovered to reduce production costs and environmental impacts.

In hydrometallurgical recycling, spent batteries are dismantled and shredded into a powder called black mass, which contains metal oxides, graphite, and other materials. The black mass is leached with sulfuric acid (H_2SO_4) and hydrogen peroxide (H_2O_2). The acid dissolves the metal oxides, while hydrogen peroxide helps reduce certain metal ions and improves their dissolution.

After leaching, sodium hydroxide (NaOH) is gradually added to raise the pH. Because different metal hydroxides precipitate at different pH ranges, the metals can be separated selectively.

Metal ion	Approximate pH at which precipitation begins
Fe^{3+}	2–3
Al^{3+}	4–5
Co^{2+}	7–8
Ni^{2+}	8–9
Mn^{2+}	9–10
Li^{2+}	Does not precipitate between pH 0–14

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Adding NaOH too quickly may cause several metals to precipitate together, reducing product purity. Organic acids, such as citric acid, may also be used because their ability to form complexes with metal ions can improve metal extraction, even though they are weaker than sulfuric acid.

Which statement is incorrect? (5 marks)

1. During leaching, H^+ ions react with metal oxides and promote the formation of dissolved metal ions.
2. Adding NaOH before leaching is complete improves metal recovery because OH^- accelerates oxide dissolution and reduces acid use.
3. Careful pH control allows selective precipitation because the metal hydroxides precipitate at different pH ranges, while Li^+ remains dissolved.
4. Citric acid may achieve effective metal extraction by forming complexes with metal ions; therefore, acid strength is not the only factor controlling leaching efficiency.

---------- End of Questions ----------

Please check your answers before submitting the answer sheet.

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Answers Keys : Science Secondary - Grade 12

No.	Answers	No.	Answers
1.	3	21.	1
2.	1	22.	2
3.	3	23.	4
4.	2	24.	4
5.	3	25.	2
6.	4	26.	3
7.	3	27.	3
8.	4	28.	3
9.	2	29.	1
10.	4	30.	2
11.	3	31.	2
12.	2	32.	2
13.	3	33.	1
14.	2	34.	4
15.	3	35.	4
16.	1	36.	3
17.	3	37.	3
18.	4	38.	4
19.	2	39.	2
20.	2	40.	2

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