Multiple Choice Test

December 4th, 2022

EXAMINATION RULES

1. You are NOT allowed to bring any personal items into the examination room, except for the water bottle, personal medicine or approved personal medical equipment.

2. You must sit at your designated desk.

3. Check the stationery items (pen, calculator, and scrap paper) provided by the organizers.

4. Do NOT start answering the questions before the “START” signal.

5. You are NOT allowed to leave the examination room during the examination except in an emergency in which case you will be accompanied by a supervisor/volunteer/invigilator. 6. If you need to visit the bathroom, please raise your hand.

7. Do NOT disturb other competitors. If you need any assistance, raise your hand and wait for a supervisor to come.

8. Do NOT discuss the examination questions. You must stay at your desk until the end of the examination time, even if you have finished the exam.

9. At the end of the examination time you will hear the “STOP” signal. Do NOT write anything more on the answer sheet after this stop signal. Arrange the exam, answer sheets, and the stationary items (pen, calculator, and scrap paper) neatly on your desk. Do not leave the room before all the answer sheets have been collected.

EXAM INSTRUCTIONS

1. After the “START” signal, you will have 3 hours to complete the exam.

2. ONLY use the pen and pencil provided by the organizers.

3. Check that your name, code and country are on your answer sheet and sign your answer sheet. Raise your hand, if you do not have the answer sheet.

4. Read each problem carefully and indicate your answer on the answer sheet using a cross (as shown below). There is only one correct answer for each question.

Example: (A) is your answer

1	A	B	C	D

5. If you want to change your answer, circle your first answer and then indicate your new answer using a cross (as shown below). You can only make ONE correction per question. More than one correction you will get no mark.

Example: (A) is your first answer and (D) is your final answer

1	A	B	C	D

6. Only the answer sheet will be evaluated. Before writing your answers on the answer sheet, use the scrap paper provided.

7. Point rules:

Correct answer : + 1 point
Wrong answer : − 0.25 point 22
No answer : no point

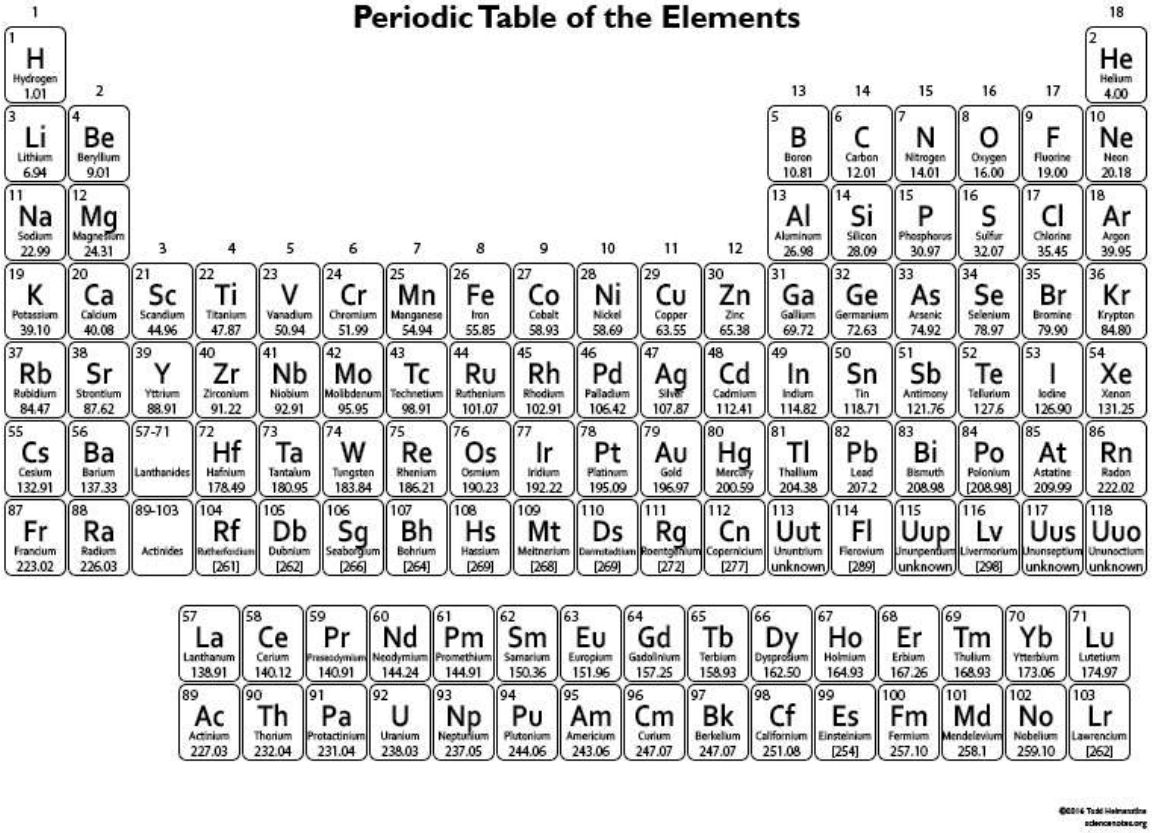
8. The total number of questions is **30**.

9. Check that you have a complete set of test pages (30 questions – 22 pages) after the “START” signal is given. Raise your hand, if you find any missing sheets.

10. Useful information for answering the questions is provided on page **4**.

GENERAL INFORMATION

constant	
Acceleration due to gravity	$g = 9.81\ m/s^2$
Universal gas constant	$R = 8.314\ \frac{J}{mol \cdot K}$
	$R = 0.08206\ L \cdot atm/mol \cdot K$
Refractive index of air	$n = 1$
Avogadro's constant	$N_A = 6.022 \times 10^{23}\ mol^{-1}$
Speed of light	$c = 2.998 \times 10^8\ m/s$
Planck's constant	$h = 6.626 \times 10^{-34}\ J \cdot s$
Specific heat capacity of water	$c_w = 4.18\ kJ/kg \cdot °C$



DO NOT turn to next page before the "START SIGNAL"
Otherwise, you will receive a penalty

1. A wagon breaks away from a train. The train continues with the same constant speed as it had and covers the distance d while the wagon comes to rest. If the wagon stops with constant acceleration, what distance does it cover?

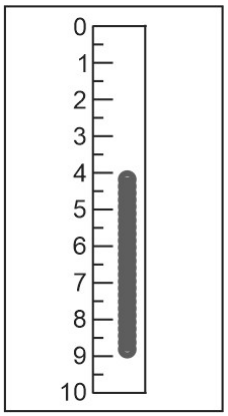
   A. $d/3$

   B. $d/2$

   C. $2d/3$

   D. d

2. Carlos wants to test the shutter speed of his camera. For this he released a very small sphere from rest in front of the zero mark of a ruler. In the image he sees a streak between 4.0 cm and 9.0 cm. What is the duration for open shutter?



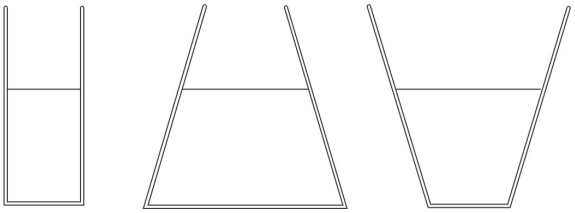
   A. 0.025 s

   B. 0.045 s

   C. 0.075 s

   D. 0.095 s

3. We have 3 containers with the shape shown in the figures, they all initially have liquid alcohol at the same height. Tell what happens to the pressure at the bottom if the liquids are heated. Assume that the heat expansion of the containers is negligible and that the alcohol does not reach its boiling temperature.



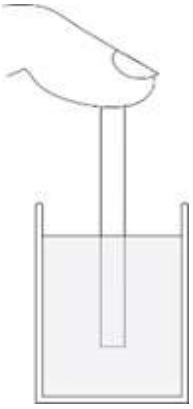
   A. It does not vary in the three cases.

   B. In all three cases it increases.

   C. In I it does not change, in II it decreases and in III it increases.

   D. In I it does not change, in II it increases and in III it decreases.

4. Half of a cylindrical pipette of length 20 cm is immersed in mercury. Its upper end is covered with a finger and after withdrawing from the mercury, part of the mercury comes out of the pipette. What is the height of the column of mercury remaining in the pipette? The atmospheric pressure equals 760 mmHg. Neglect capillary effects and heat transfer from the finger to the pipette.



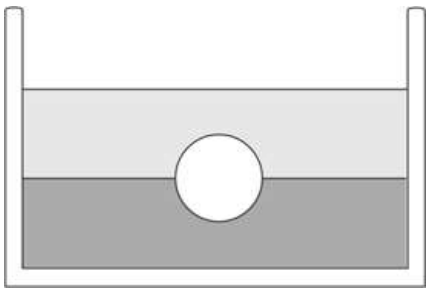
A. 1.8 cm

B. 4.5 cm

C. 8.7 cm

D. 9.3 cm

5. A layer of mercury is poured into a container and another layer of oil is poured on top. A homogeneous sphere is introduced into the container and when it reaches equilibrium it floats so that exactly half its volume is submerged in the mercury. Determine the density of the ball material if the density of mercury is 13.6 g/cm^3 and of oil 0.90 g/cm^3.



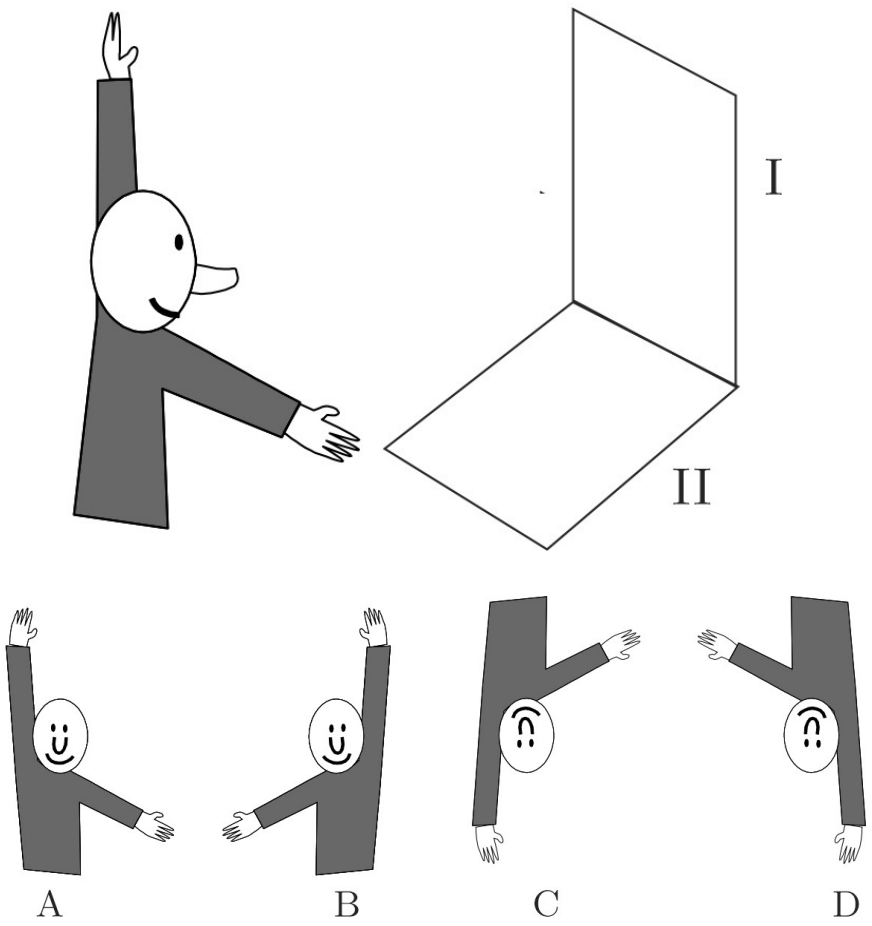
A. 6.35 g/cm^3

B. 7.25 g/cm^3

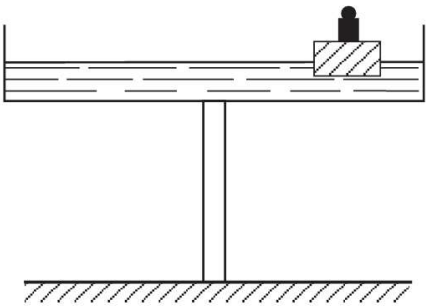
C. 11.3 g/cm^3

D. 12.7 g/cm^3

6. Two mirrors I and II are perpendicular. Gabriel is in front of the mirror I. What image does Gabriel see of himself in mirror II, coming from the reflection from mirror I?



7. A wide vessel containing water is in equilibrium placed on a thin vertical bar. A piece of wood and a weight are carefully placed on the surface of the water so that both float on the surface of the water, as shown in the figure.



The vessel

A. will lean towards the side on which the piece of wood was placed with the weight.

B. will lean to the opposite side that the piece of wood with the weight was placed on.

C. will oscillate.

D. will not lose its horizontal position.

8. At what length does a copper cable suspended vertically from one end break under its own weight? The maximum force per unit area that copper can withstand while being pulled before breaking is 8.0×10^8 N/m^2. The density of copper is 7.9 g/cm^3.

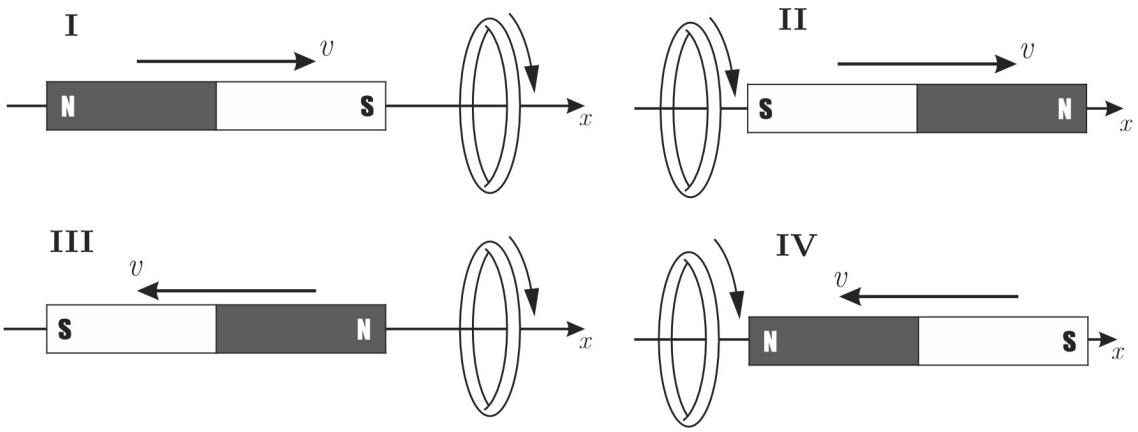
A. 3.2×10^2 m

B. 6.3×10^2 m

C. 2.9×10^3 m

D. 1.0×10^4 m

9. A magnet moves along the axis of a conducting ring, as shown in the figures. On the rings the directions of induced electric currents are represented. Which situations are correct?



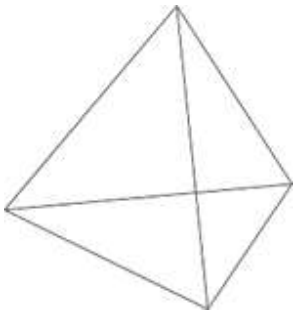
A. Only II and III are correct

B. Only I and IV are correct

C. All are incorrect

D. All are correct

10. Find the electric resistance between two vertices of a tetrahedron if the electric resistance of each edge is R.



A. $R/2$

B. $R/3$

C. $R/4$

D. $R/5$

11. Miners use atomic absorption spectroscopy to measure the concentration of trace elements in crushed rock samples. This technique measures the absorption of light of characteristic wavelengths that occurs when an electron in the elements' ground state absorbs light energy to be excited to a higher electron energy level. Determine the correct ground state electron configuration of the following atoms and ions S^{2-}, Ni^{2+} and Si respectively.

A. $1s^2 2s^2 2p^6 3s^2 3p^6$; $[Ar]3d^8 4s^2$; $1s^2 2s^2 2p^6 3s^2 3p^4$

B. $1s^2 2s^2 2p^6 3s^2 3p^4$; $[Ar]3d^8 4s^2$; $1s^2 2s^2 2p^6 3s^2 3p^2$

C. $1s^2 2s^2 2p^6 3s^2 3p^4$; $[Ar]3d^8$; $1s^2 2s^2 2p^6 3s^2 3p^4$

D. $1s^2 2s^2 2p^6 3s^2 3p^6$ $[Ar]3d^8$; $1s^2 2s^2 2p^6 3s^2 3p^2$

12. *Acidothiobacillus ferroxidans* has infected the waste heaps of processed sulphide ore at the Cerro Matoso mine. This bacterium oxidises sulphides to form sulphuric acid. Water with a pH of 7.0, was sprayed on this heap at a rate of 100 L/hr the resulting leachate has a pH of 1.95. Determine the rate at which the *Acidothiobacilli* are oxidising the sulphide ore in moles of sulphide per hour. Assume the sulphuric acid completely dissociates to sulphate(vi) ions

A. 0.38 mol/hour

B. 0.56 mol/hour

C. 1.1 mol/hour

D. 2.2 mol/hour

13. A blasting explosive is made on site from 94.5% by mass of ammonium nitrate(V) and 5.50% by mass of Octene, C_8H_{16}. The only products of the explosive reaction are nitrogen, water and carbon dioxide gasses. What is the balanced equation for this explosive reaction?.

A. $6NH_4NO_3 + C_8H_{16} \rightarrow 8CO_2 + 6N_2 + 24H_2O$

B. $8NH_4NO_3 + C_8H_{16} \rightarrow 8CO_2 + 8N_2 + 24H_2O$

C. $16NH_4NO_3 + C_8H_{16} \rightarrow 8CO_2 + 16N_2 + 32H_2O$

D. $24NH_4NO_3 + C_8H_{16} \rightarrow 8CO_2 + 24N_2 + 56H_2O$

14. Some harder rock requires a more powerful explosive such as nitro-glycerine ($C_3H_5N_3O_9$) that explodes to form carbon dioxide, nitrogen, oxygen and water only. When detonated in the rock the nitro-glycerine produces these gasses at 160 °C. What mass of nitro-glycerine is required to produce 24.0 liters of gas in the explosion at 400kPa?

A. 83.5 g

B. 226 g

C. 151 g

D. 8.46 kg

15. Lead (II) Azide, $Pb(N_3)_2$ can be used as a detonator, as it easily thermally decomposes to lead and nitrogen gas, with ΔHr = -463 kJ/mol. The azide ion has four lone pairs of electrons and the Nitrogen molecule's bond energy is 946 kJ/mol. The ionic bond energy of Lead (II) Azide is 516 kJ/mol and the metallic bond energy of lead metal is 190 kJ/mol. Determine the nature and energy of the bonds in the azide (N_3^-) ion.

A. One single N-N bond and one double N=N bond, with energies 278 kJ/mol and 518 kJ/mol respectively

B. Two N=N double bonds each with a bond energy of 748 kJ/mol

C. One single N-N bond and one double N=N bond, with energies 278 kJ/mol and 748 kJ/mol respectively

D. Two N=N double bonds each with a bond energy of 513 kJ/mol

16. The water from the deep sections of the mine is found to contain 0.035 mg/L of Cadmium, in the divalent form. The mine engineer wants to remove these toxic ions by precipitation with sodium hydroxide to reach a safe drinking water standard of 0.005mg/L for cadmium (WHO drinking water standards). The Solubility Products for cadmium hydroxide is 7.20×10^{-15} mol^3/L^3. Determine how much sodium hydroxide the engineer will need to treat 1000 liters of this water (assume the water has a pH of 7.0 before treatment).

A. 16.09 g

B. 29.99 g

C. 0.0225 g

D. 0.0065 g

17. During the corrosion of iron the metal is oxidized by oxygen in the presence of water to form hydrated iron (III) hydroxides. The mine is kept damp to suppress the dust so the mild steel trolleys used to transfer ore start to corrode. Which of the following changes would best reduce this rate of corrosion.

    A. Adding an oxidant such as manganate(VII) ions to the water, painting the trolleys and adding zinc handles to the trolleys.

    B. Adding an oxygen scavenger such as sulfate (IV) ions to the water, painting the trolleys and adding zinc handles to the trolleys.

    C. Adding an oxidant such as manganate(VII) ions to the water, painting the zinc handles of the trolleys.

    D. Cleaning the trolleys after use with pure water, coating the trolleys with grease and adding aluminum handles to the trolleys.

18. One of the steps required for extraction of nickel at the Cerro Matoso mine involves electrorefining, using an impure nickel anode (composition 90.0% Ni, 8.20% Cu, 1.60% Fe and 0.30% Ag by mass) and a pure nickel cathode with a nickel(II) chloride/sulfate electrolyte washed through the cell. If a current density of 2.00 kA/m^2, a low voltage and electrodes with 0.65m^2 area are used. Estimate the rate of electrodeposition of nickel on the cathode. (The Charge on a mole of electrons is 96450 C, and any iron that is oxidised will form 3+ ions)

    A. 0.385 g/s

    B. 0.396 g/s

    C. 0.355 g/s

    D. 0.547 g/s

19. In the refining process a 150 kg/hr stream of platinum 65.0% (m/m),and palladium 35.0% is heated from 140 °C to 1790 °C to liquefy these metals. Estimate the power required to achieve this – assuming no thermal losses. (Cp = specific heat capacity, Hf = latent heat of fusion, Ar = relative atomic mass)

Metal	Melting Point C		Cp (solid) J/mol.K	Cp (liquid) J/mol.K	Hf kJ/mol		Ar
Pt	1770		25.9	39.0	22.2		195
Pd	1560		24.4	40.5	16.7		106

A. 19.0 kW

B. 17.4 kW

C. 13.6 kW

D. 12.8 kW

20. The mine uses mechanical ore transporters powered by petrol engines. These engines are tuned to almost completely combust the octane (petrol C_8H_{18}) with a small amount of carbon monoxide produced from incomplete combustion. When tuning these engines, 912 g of octane was used to combust 3840 L of oxygen, and produced 2560 L of carbon based gasses at the same conditions of temperature and pressure. What was the mole ratio of carbon monoxide to carbon dioxide in the exhaust?

A. 1:3

B. 1:1

C. 1:7

D. approximately no Carbon monoxide

21. Many of the miners working in Colombia have a diet high in maize which when combined with higher levels of sugar in their diets has lead to an increase in the incidence of Diabetes mellitus among these adult people. Which are the changes in the body in this group of people, that are associated with this disease?

A. The beta cells in the pancreas secrete insulin when higher levels of glucose are detected in the blood, which causes the person to increase the absorption of glucose into cells in their body.

B. The person generally becomes thinner, dehydrated and has urine with higher levels of ketones

C. The beta cells in the pancreas secrete insulin when higher levels of glucose are detected in the blood, however cells in the body have become insensitive to insulin and so do not increase their absorption of glucose from the blood.

D. The person is often overweight with a high BMI and produces sufficient insulin into the blood to cause the absorption of glucose.

22. *Acidothiobacillus* species (*thiooxidans* and *ferrooxidans*) are used to extract minerals from the crushed rock in mine dumps. These bacteria oxidise iron(II) and sulphide ores as a source of electrons to fuel their electron transport chains and produce energy. In this process they release metal and hydrogen ions into the surrounding water. Genetic analysis of these bacteria indicates they contain genes for the enzymes of the Calvin cycle and the fixation of nitrogen. Which terms best define these bacteria?

A	Chemotroph	Lithotroph	Acidophile	Producer
B	Autotroph	Lithotroph	extremophile	Primary consumer
C	Phototroph	Autotroph	Acidophile	Decomposer
D	heterotroph	Autotroph	extremophile	Secondary consumer

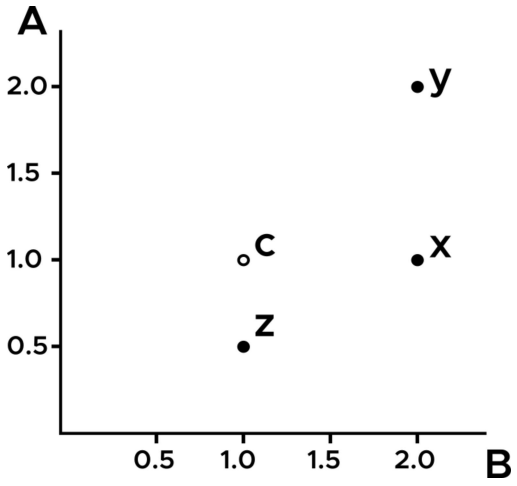
23. Identify the likely seed characteristics for the two seeds that depend on different dispersal mechanisms. The first seed depends on wind dispersal and the second on dispersal via ruminants.

	Wind dispersed seed	**Seed dispersed via ruminant**
A	Dense nut with woody pericarp	Very light, spiral feathers
B	Small dense pip in ballistic pod under tension	Multiple fine hairs coat the outside with hooks
C	Dense fire-resistant seed coat	Fleshy fruit coated in small seeds
D	Rotary wing, small	Drupe fruit, coloured, hard inner seed coat

24. The tall wax palms (*Ceroxylon quindiuense*) are indigenous trees of Colombia. In these growing trees some cells are sampled and analyzed, the number of chromosomes and the number of DNA molecules in the cells are compared to cells of this tree in the G1 phase of the cell cycle (C: reference cells). Identify the phase of the cell cycle that groups x, y and z come from. (note sister chromatids bound by a centromere are considered as one chromosome but two DNA molecules).

A axis: relative number of chromosomes

B axis: relative number of DNA molecules



	X cells	Y cells	Z cells
A	Prophase of mitosis	Prophase of meiosis II	Anaphase of Meiosis II
B	G2 phase	Anaphase of mitosis	Cytokinesis of Meiosis I
C	Metaphase of mitosis	Cytokinesis of mitosis	Prophase of Mitosis
D	Anaphase of meiosis I	Metaphase of meiosis I	Prophase of Meiosis 1

25. The mine stores have several cats to control rodent pests. Cat coat colour and hair length are controlled by several genes: the gene for the black or orange coat is located on the X chromosome, cats can be orange, black, or black and orange (known as tortoiseshell). The Agouti gene codes for bands of colour within individual hairs with the dominant allele producing bands of colour and the recessive allele coding for hairs of a single solid colour. There are three phenotypes for hair length: medium, short, or long. Hair length is controlled by a single gene and the heterozygous animal has medium length hair.

If a medium length hair, solid black male cat mates with a long-haired tortoiseshell agouti female which of the following statements about the kittens are correct?

i. One quarter of the male kittens will be orange.

ii. All the female kittens will be able to have black babies.

iii. All the kittens will have agouti banded fur.

iv. At least 50% of the kittens will have agouti banded fur.

v. No kittens will have short hair.

vi. 25% of the kittens may have medium length hair.

A. i, iii, and v

B. i, ii and iv

C. ii, iv and v

D. ii, iii, v

26. In the tall Wax palms of Colombia water is drawn up from the roots to the top of these 45 -60m trees. Assuming that water only moves by transpiration, identify the conditions in the vascular tissues that result in the movement of water to the top of these trees. (Water potential difference)

	% of xylem water flow used in photosynthesis	Water potential in xylem tissue at palm leaves	Water potential in xylem tissue at palm roots
A	More than 30%	Slightly positive	Highly positive
B	Less than 10%	Slightly positive	Highly positive
C	More than 30%	Very negative	Slightly negative
D	Less than 10%	Very negative	Slightly negative

27. Many of the miners working at Las Cunas emerald mine are native Andean men. In general Andean highlanders (Aymara people) have been found to have an enhanced total lung volume when compared to sea level dwelling Americans.There are two principal hypotheses attempting to explain the relative increase in total lung volume:

The first hypothesis is, a genetic mutation favoured by the altitude of the Andean mountains;

The second hypothesis is, this is a physiological adaptation developed when living at high altitudes. Further research has demonstrated that an increasing proportion of Aymara ancestry correlates with increased lung capacity, and that the total lung volume of Aymara men raised at sea level is not as large as that of Aymara males raised at high altitude. Which hypothesis do these observations support?

A. the hypothesis that the greater lung volume is based on genetic inheritance

B. The hypothesis that altitude hypoxia causes the men to adapt and increase total lung volume

C. The observations support neither hypothesis

D. The Observations support both hypotheses

28. Several major rivers flow from inside Colombia to the ocean, and the fish that inhabit these waters need to manage the concentrations of salts in their bodies. Species such as Tilapia *oreochromis* a freshwater fish, *Lutjanus colorado* a marine fish, *Chaetaster nodosus* starfish (an invertebrate) and *Centropomas armatus* an euryhaline fish (live in marine and freshwater) show many adaptations. Identify how these species manage these concentrations of salts by selecting the letter corresponding to appropriate management strategy for that species.

Management strategies:

i. Larger volume of glomeruli / Bowman's capsules

ii. Fewer nephrons

iii. Enhanced salt recovery via chloride cells

iv. Enhanced salt excretion via chloride cells

v. Increased drinking of water

vi. Little or no drinking of water

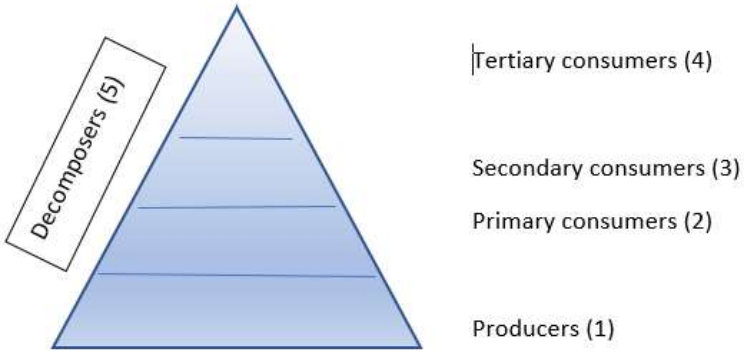
vii. All of the above

viii. No management strategies (none of the above)

	Starfish	Marine fish	Tilapia	Euryhaline
A	i, ii, iii,	i, ii, iii,	iv, v	vii
B	vii	iv, v	i, ii, iii,	i, ii, v, iv
C	iii	i, ii, iii	iv, v	iii, iv
D	viii	iv, v	i, ii, iii,	vii

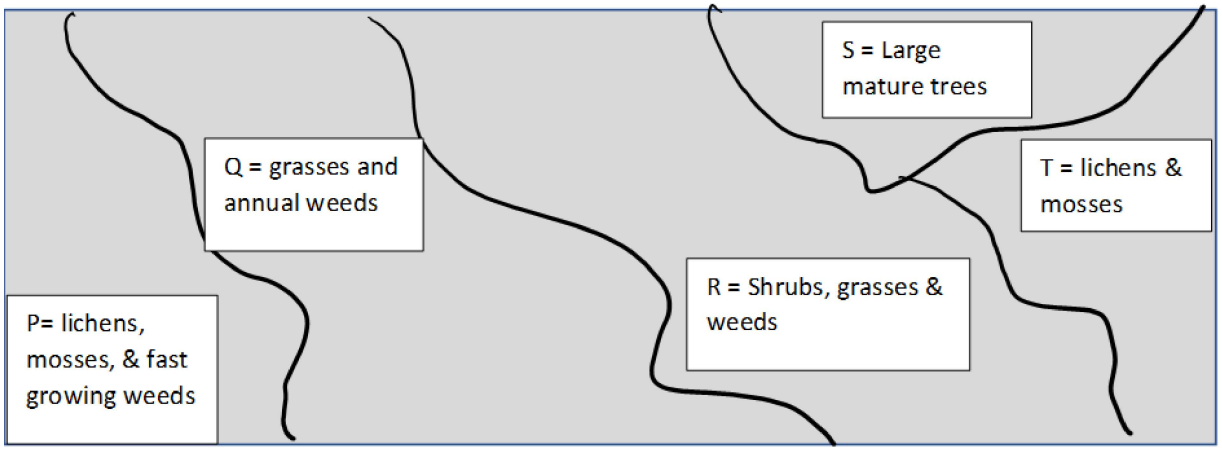
29. The Amazonian rainforest is one of the most complex and diverse ecosystems in the world. Identify the correct trophic level (or levels for those that fit in several for the following species from this rainforest:

Note endophytic fungi live inside the roots of plants forming a symbiotic mutualism with the plant.



	Harpy Eagle	Saprophytic fungi	Leaf cutter ant	Mahogany tree	Orb spider	Endophytic fungi
A	3	5	2	1	3 & 4	5
B	4	5	2 & 3	2	3	3
C	3	1	4	3	2	5
D	4	5	2 & 3	1	3 & 4	2

30. Ecological succession of the mine waste dump – hypothesis formed from data The Cerro Matoso mine is deep and one of the largest in the world and has generated very large mine dumps of the crushed rock without any organic matter, after mineral extraction. A species survey of this mine dump is shown below.



i. This mine dump demonstrates a secondary ecological succession

ii. Lichens and mosses are pioneer species

iii. The age of the dump increases from left to right

iv. Zone S has reached ecological climax

v. Zone T could be a zone of crushed rock that has a composition that makes it much more difficult to colonize.

Select the option that best explains this survey.

A	ii and v
B	i,ii, iii and iv
C	ii, iii, iv and v
D	i,iii, iv and v