



Points: 30

Time: 3 Hours

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# Science for Sustainable Food and Agriculture

## Multiple Choice Test

December 3, 2023

You may turn to the next **TWO** pages to  
read the “EXAMINATION RULES” and “EXAM INSTRUCTIONS”

## EXAMINATION RULES

1. You are **NOT** allowed to bring any personal items into the examination room, except for personal medicine or approved personal medical equipment.
2. You must sit at your designated desk.
3. Do **NOT** start reading or answering the questions before the “**START**” signal.
4. 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.
5. If you need to visit the bathroom, please raise the “fan” provided on the table.



provided “fan”

6. Do **NOT** disturb other competitors. If you need any assistance, raise your “fan” and wait for a supervisor to come.
7. 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.
8. At the end of the examination time you will hear the “**STOP**” signal. You are **NOT** allowed to write anything after the signal is given. Arrange the exam, answer sheets, and the stationery items (pen, pencil, eraser, calculator, and fan) neatly on your desk. Do **NOT** leave the room before all the answer sheets have been collected, and you are given the signal to leave.
9. There will be only one warning if you do not comply with the examination rules. Any failure to comply with the rules or instructions of supervisors after the warning results in disqualification, receiving total of zero points in the multiple choice test.

**You may turn to the exam instructions on the next page**

## EXAM INSTRUCTIONS

1. After the “START” signal, you will have 3 hours to complete the exam.
2. Check the stationery items (pen, pencil, eraser, calculator, and fan) provided by the organizers. ONLY use the pen and pencil provided by the organizers.
3. No additional scratch paper is provided. You may use the question sheets and their backside as scratch paper.
4. Check that your name, code and country are on your answer sheet and sign your answer sheet. Raise your “fan”, if you do not have the answer sheet.
5. Read each problem carefully and indicate your answer on the answer sheet by filling in the circle for the answer only with PENCIL (as shown below). There is only one correct answer for each question.

*Example: (B) is your answer.*



6. If you want to change your answer, completely erase your first answer and fill in your new answer. Any ambiguous answers are marked as wrong.
7. Only the answer sheet will be evaluated. Before filling in your answers on the answer sheet, use the question sheets as scratch paper.
8. Point rules
  - Correct answer : + 1 point
  - Wrong answer : - 0.25 points
  - No answer : 0 points
9. Check that you have a complete set of the exam question sheets after the “START” signal is given. Raise your “fan”, if you find any missing sheets. There are total of **30 questions in 36 pages total** including front cover and instruction pages. There is only **one page** of the answer sheet.
10. Useful information is provided on the following page.

**DO NOT turn to the next page before the**

**"START SIGNAL"**

## GENERAL INFORMATION

**Periodic Table of the Elements**

1																			18
1 H Hydrogen 1.01														2 He Helium 4.00					
3 Li Lithium 6.94	4 Be Beryllium 9.01											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18		
11 Na Sodium 22.99	12 Mg Magnesium 24.31											13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.07	17 Cl Chlorine 35.45	18 Ar Argon 39.95		
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 51.99	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.63	33 As Arsenic 74.92	34 Se Selenium 78.97	35 Br Bromine 79.90	36 Kr Krypton 84.80		
37 Rb Rubidium 84.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.95	43 Tc Technetium 98.91	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.6	53 I Iodine 126.90	54 Xe Xenon 131.25		
55 Cs Cesium 132.91	56 Ba Barium 137.33	57-71 Lanthanides	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.09	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium [208.98]	85 At Astatine 209.99	86 Rn Radon 222.02		
87 Fr Francium 223.02	88 Ra Radium 226.03	89-103 Actinides	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium unknown	114 Fl Flerovium [289]	115 Uup Ununpentium unknown	116 Lv Livermorium [293]	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown		
57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium 144.91	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.05	71 Lu Lutetium 174.97					
89 Ac Actinium 227.03	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium 237.05	94 Pu Plutonium 244.06	95 Am Americium 243.06	96 Cm Curium 247.07	97 Bk Berkelium 247.07	98 Cf Californium 251.08	99 Es Einsteinium [254]	100 Fm Fermium 257.10	101 Md Mendelevium 258.1	102 No Nobelium 259.10	103 Lr Lawrencium [262]					

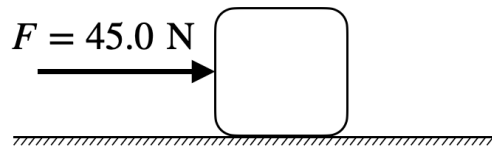
### Constants

acceleration due to gravity (g)	9.80 m s <sup>-2</sup>
gas constant (R)	8.31 J mol <sup>-1</sup> K <sup>-1</sup> 0.082 atm L mol <sup>-1</sup> K <sup>-1</sup>
0 °C	273.15 K
Faraday constant (F)	96,500 C mol <sup>-1</sup>

### Formulas

area of a circle	A = πr <sup>2</sup>	heat	Q = mcΔT
circumference of a circle	C = 2πr	Ohm's law	V = IR
volume	V = Ah	gravitational potential energy	E <sub>p</sub> = mgh
density	$\rho = \frac{m}{V}$	power	$P = \frac{E}{t}$
pressure	$p = \frac{F}{A}$		

1. A box with a weight of 100 N is at rest on a horizontal surface. The coefficient of kinetic friction and the coefficient of static friction between the box and the surface are  $\mu_k = 0.400$  and  $\mu_s = 0.500$ , respectively. If the box is pushed to the right by the force  $F = 45.0$  N as shown in the figure, what is the magnitude and direction of the friction acting on the box?



A.	45.0 N to the left
B.	40.0 N to the right
C.	50.0 N to the left
D.	50.0 N to the right



Points: 30

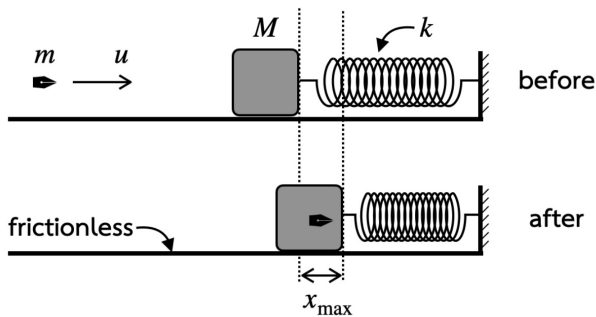
Time: 3 Hours

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2. Which object has the greatest magnitude of the acceleration? Assume that all objects move with constant acceleration in straight line.

A.	A vehicle accelerates from rest to 100 km/h within 4.00 s.
B.	A rock during a free fall near the surface of the Earth.
C.	A vehicle with an initial speed of 60.0 km/h comes to rest in 3.20 s.
D.	A vehicle starting from rest takes 6.50 s to cover a distance of 250 m.

3. A bullet of mass  $m$  is shot into a stationary block of mass  $M$ . The block rests on a frictionless floor and is attached to a massless spring with a spring constant  $k$ . The bullet embeds itself in the block upon impact. Subsequently, the combined mass compresses the spring to a maximum displacement of  $x_{\max}$ , as illustrated in the figure. Determine the initial velocity  $u$  of the bullet in terms of  $m$ ,  $M$ ,  $k$  and  $x_{\max}$ .



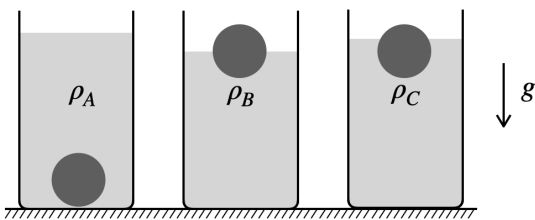
A.	$\frac{x_{\max}}{m} \sqrt{k(m+M)}$
B.	$\frac{(m+M)}{m} x_{\max} \sqrt{k}$
C.	$x_{\max} \sqrt{\frac{k}{m}}$
D.	$x_{\max} \sqrt{\frac{k}{m+M}}$

4. When placed in a liquid of density  $\rho_A$ , a sphere sinks and displaces a volume  $V_A$  of liquid.

When placed in a liquid of density  $\rho_B$ , the same sphere floats with half of its volume appears over the surface of the liquid.

When placed in a liquid of density  $\rho_C$ , the same sphere floats.

Determine the magnitude of the buoyant force exerted by the liquid of density  $\rho_C$  on the sphere.

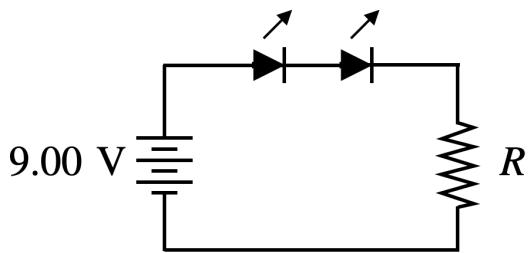


A.	$\rho_C V_A g$
B.	$(1/2)\rho_A V_A g$
C.	$(1/2)\rho_B V_A g$
D.	inconclusive

A.	$\rho_C V_A g$
B.	$(1/2)\rho_A V_A g$
C.	$(1/2)\rho_B V_A g$
D.	inconclusive

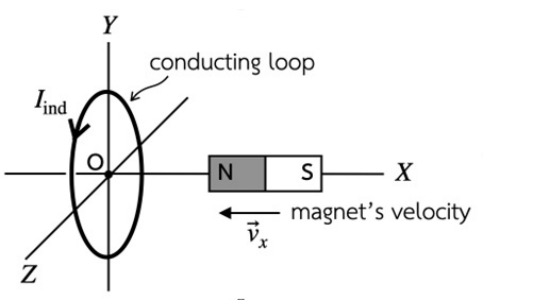
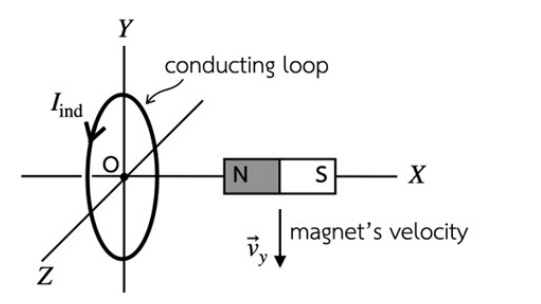
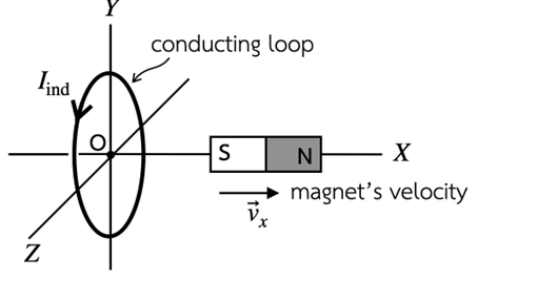
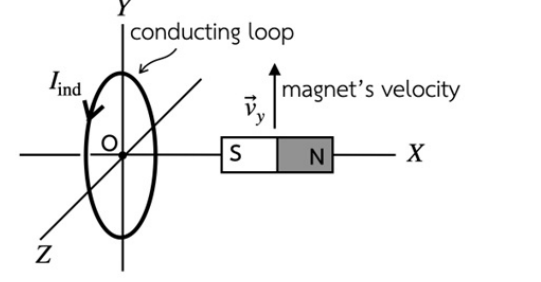


5. Two identical LEDs are connected as shown in the circuit diagram. Each LED needs a current of 10.0 mA and a potential difference of 1.20 V to operate correctly. Calculate the resistance of a resistor  $R$  for this circuit to operate under the condition given above.

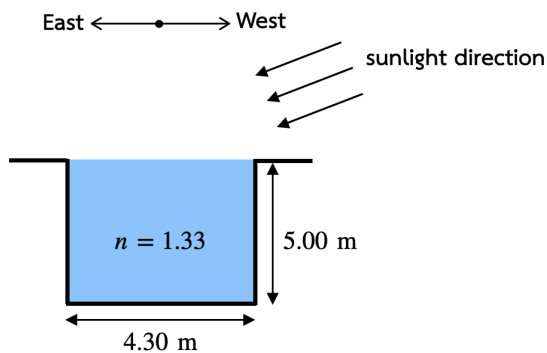


A.	330 $\Omega$
B.	390 $\Omega$
C.	660 $\Omega$
D.	780 $\Omega$

6. Identify the diagram that shows the **incorrect** direction of the induced current  $I_{ind}$  in the conducting loop.

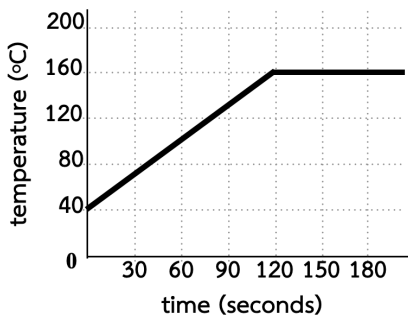
A.		B.	
C.		D.	

7. The rectangular pool measuring 4.30 meters in width and 5.00 meters in depth is filled with water to the top. As shown in the figure, the 4.30-meter side aligns with the East-West direction. The pool is situated near the equator, where the Sun is directly overhead at noon. At approximately what time will the bottom of the pool begin to be entirely shaded? Given that the index of refraction of water is 1.33.



A.	3:00pm
B.	3:30pm
C.	4:00pm
D.	4:30pm

8. An insulated container holds 200 grams of solid thermoplastic. Heat is supplied to the thermoplastic at a constant rate of 400 J/s. The temperature of the thermoplastic is measured and recorded, and the results are presented in the graph below.



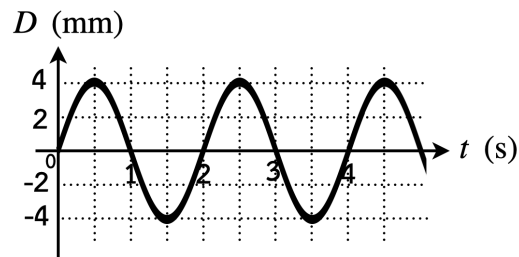
Consider the following statements:

- I. The specific heat of this thermoplastic is 2.00 kJ/(kg K).
- II. The melting point of this thermoplastic is 160 °C.
- III. After 120 seconds, only liquid form of the thermoplastic is in the container.
- IV. The specific latent heat of fusion of this thermoplastic is 12.0 kJ/kg.

Which of these statements is true?

A.	I and II only
B.	II and III only
C.	I, II and IV only
D.	I, II and III only

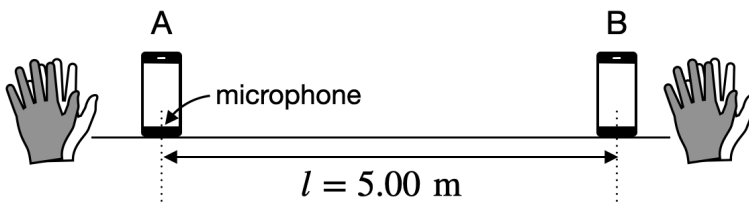
9. The graph below shows the displacement ( $D$ ) of a medium at  $x = 0.0$  cm as a function of time ( $t$ ) for a wave traveling in the  $+x$  direction at a speed of  $5.0$  cm/s. Determine the wavelength of this wave.



A.	1.0 cm
B.	2.0 cm
C.	5.0 cm
D.	10 cm

10. A smartphone can be used as an acoustic stopwatch. It measures the time interval between two consecutive sound events captured by its microphone. The timing starts when the first sound pulse reaches the microphone and stops when the second sound pulse is detected.

In an experiment aimed at measuring the speed of sound in the air ( $v = 340 \text{ m/s}$ ), two smartphones in acoustic stopwatch mode are placed with their microphones located at a distance  $l = 5.00 \text{ m}$  apart, as shown in below figure. During the measurement, one student claps next to the microphone of phone A, and a few seconds later, another student claps next to the microphone of phone B. Each clap triggers both phones but at different moments due to the time it takes for the sound waves to travel. Which of the following are a possible correct pair of readings from phone A and phone B?



A.	Phone A: 0.0147 s, Phone B: 0.0147 s
B.	Phone A: 1.0147 s, Phone B: 1.0000 s
C.	Phone A: 3.1000 s, Phone B: 3.1294 s
D.	Phone A: 2.1294 s, Phone B: 2.1000 s

11. Use data from the table to answer the question.

Indicator	$K_A$ of indicator at 25°C	Color change (acid form to basic form)
Bromophenol blue	$1.4 \times 10^{-4}$	Yellow → Blue
Bromocresol green	$2.1 \times 10^{-5}$	Yellow → Blue

Colors of both bromophenol blue and bromocresol green turn yellow when the ratio of acid form: basic form is greater than 25:1, while they turn blue when the ratio of basic form: acid form is greater than 5:1. Both indicators are green in between the pH that corresponds to 25:1 and 5:1 ratios. What is the color a solution of bromophenol blue would have at the same pH at which at the solution containing both compounds is green?

- A. Blue
- B. Green
- C. Yellow or Green
- D. Green or Blue

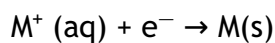
12. From the following observations under standard conditions:

- i. Metal M dissolves in  $\text{H}_2\text{SO}_4$  (aq), but not in  $\text{HCl}$  (aq).
- ii. Metal M displaces  $\text{Ag}^+$  (aq), but not  $\text{Sn}^{4+}$  (aq).

When

$2\text{H}^+ + 2\text{e}^-$	$\rightarrow$	$\text{H}_2$	$E^\circ_{\text{red}} = 0.00 \text{ V}$
$\text{Sn}^{4+} + 2\text{e}^-$	$\rightarrow$	$\text{Sn}^{2+}$	$E^\circ_{\text{red}} = 0.13 \text{ V}$
$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$	$\rightarrow$	$\text{SO}_2 + 2\text{H}_2\text{O}$	$E^\circ_{\text{red}} = 0.20 \text{ V}$
$\text{Ag}^+ + \text{e}^-$	$\rightarrow$	$\text{Ag}$	$E^\circ_{\text{red}} = 0.80 \text{ V}$

Estimate the value of  $E^\circ_{\text{red}}$  of the half reaction:



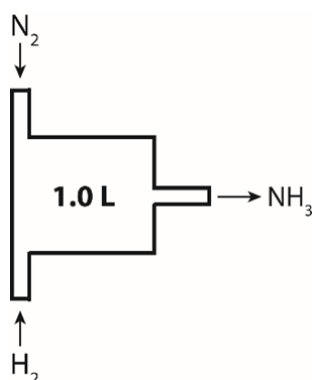
- A.  $0.00 < E^\circ$
- B.  $0.00 < E^\circ < 0.13$
- C.  $0.13 < E^\circ < 0.20$
- D.  $0.20 < E^\circ < 0.80$



13. A sample of 0.5 g silver metal is obtained from two different silver sources. Source 1 has two stable isotopes,  $^{107}\text{Ag}$  (106.91 g/mol) and  $^{109}\text{Ag}$  (108.90 g/mol), with isotope abundance of 51.84% and 48.16%, respectively. Source 2 contains  $^{107}\text{Ag}$  (106.91 g/mol) and  $^{109}\text{Ag}$  (108.90 g/mol), with isotope abundance of 44.80% and 55.20%, respectively. If the isotope ratio ( $^{107}\text{Ag}$ : $^{109}\text{Ag}$ ) in the silver sample is 1:1, determine the percentage by mass of silver from source 2 in the sample.

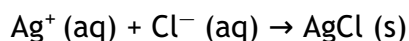
- A. 12%
- B. 26%
- C. 32%
- D. 51%

14. Assume that the reactor under the condition given below starts at vacuum, and then  $N_2$  and  $H_2$  are fed at constant rates of 2.0 g/min and 0.43 g/min for  $N_2$  and  $H_2$ , respectively. Once 8.4 g of  $N_2$  is accumulated in the reactor, ammonia is selectively removed from the reactor at a constant rate to maintain a chemical equilibrium within the reactor. If the equilibrium constant  $K_c$  of this reaction is 3.0 at this temperature, how many grams of ammonia are present in the reactor at any given time?



- A. 4.8 g
- B. 8.4 g
- C. 10 g
- D. 14 g

15. A student prepares a 1.0 M solution of  $\text{PtCl}_4 \cdot 5\text{NH}_3$ . The student first tests the conductivity of the solution and it conducts electricity equivalent to the solution of 4.0 M of ions. The student titrates 10.00 cm<sup>3</sup> of 1.0 M solution of  $\text{PtCl}_4 \cdot 5\text{NH}_3$  with a 1.5 M silver solution and 20.00 cm<sup>3</sup> of 1.5 M  $\text{Ag}^+$  is required to reach the end point. A titration was performed to determine the amount of  $\text{Cl}^-$  in the solution according to this reaction.



What are the possible species in the prepared  $\text{PtCl}_4 \cdot 5\text{NH}_3$  solution?

- A.  $[\text{Pt}(\text{NH}_3)_5\text{Cl}]^{3+} (\text{aq}) + 3\text{Cl}^- (\text{aq})$
- B.  $[\text{Pt}(\text{NH}_3)_2\text{Cl}_4] (\text{aq}) + 3\text{NH}_3 (\text{aq})$
- C.  $[\text{Pt}(\text{NH}_3)_5]^{4+} (\text{aq}) + 4\text{Cl}^- (\text{aq})$
- D.  $[\text{Pt}(\text{NH}_3)_4\text{Cl}_2]^{2+} (\text{aq}) + 2\text{Cl}^- (\text{aq}) + \text{NH}_3 (\text{aq})$

16. Element X is in the third period of the periodic table. The data for successive ionization energy of the element X are  $IE_1 = 1012$  kJ/mol,  $IE_2 = 1907$  kJ/mol,  $IE_3 = 2914$  kJ/mol,  $IE_4 = 4964$  kJ/mol,  $IE_5 = 6274$  kJ/mol,  $IE_6 = 21268$  kJ/mol, and  $IE_7 = 25431$  kJ/mol. Which of the following statements is correct?

- A. Chloride of the element X has a square planar geometry.
- B. Chemical formula for oxide of the element X is  $X_4O_{10}$ .
- C. Aqueous solution of oxide of the element X turns red litmus paper blue.
- D. Possible sets of quantum numbers of two electrons of the element X in the ground state are  $(n = 3, l = 1, m_l = -1, m_s = \frac{1}{2})$  and  $(n = 3, l = 1, m_l = -1, m_s = -\frac{1}{2})$ .

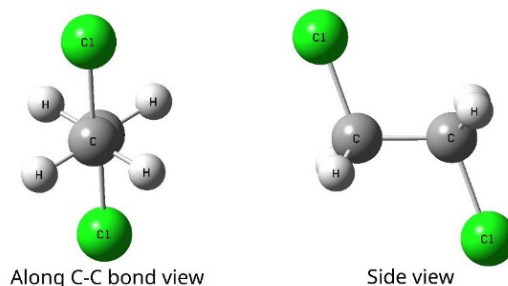
17. If only  $\alpha$  and  $\beta^-$  particles (electrons) are emitted during the following natural radioactive decays:

- i.  ${}_{90}^{232}\text{Th} \rightarrow {}_{82}^{208}\text{Pb}$
- ii.  ${}_{92}^{235}\text{U} \rightarrow {}_{82}^{207}\text{Pb}$
- iii.  ${}_{93}^{237}\text{Np} \rightarrow {}_{83}^{209}\text{Bi}$
- iv.  ${}_{92}^{238}\text{U} \rightarrow {}_{82}^{206}\text{Pb}$

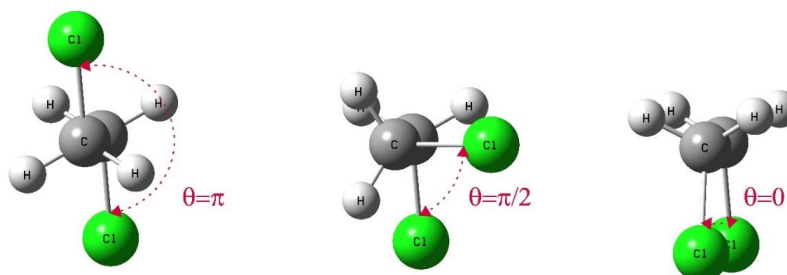
Which decay processes emit the fewest  $\alpha$  and the most  $\beta^-$  particles, respectively?

- A. i and ii
- B. iii and iv
- C. i and iv
- D. ii and iii

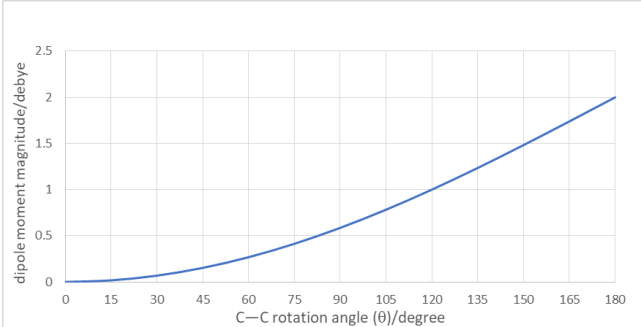
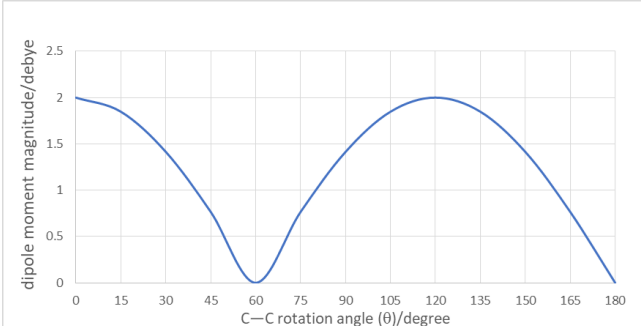
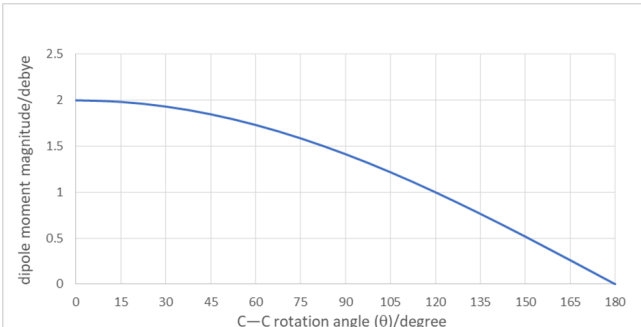
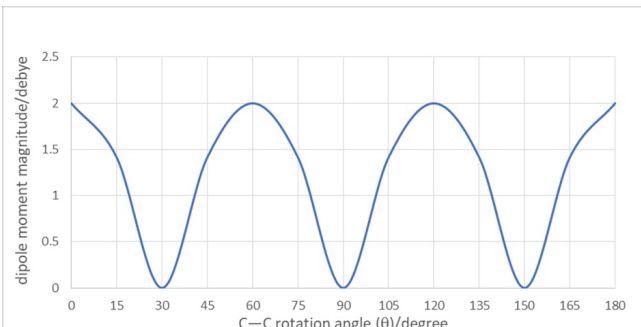
18. 1,2-dichloroethane or ethylene dichloride (EDC) is a precursor to vinyl chloride which is used to produce polyvinyl chloride (PVC). Its structure is shown below.



The C–C bond rotation in EDC can occur almost freely. This can be thought of as having one CH<sub>2</sub>Cl group stationary and having another CH<sub>2</sub>Cl rotating around the C–C axis. Figure below shows the change of molecular structure as the function of C–C rotation angle ( $\theta$ ) viewed along the C–C bond.



Which is the correct plot of dipole moment magnitude as the function of C–C rotation angle ( $\theta$ )

A.	
B.	
C.	
D.	

19. A gas mixture with the total mass of 168 g consists of propane ( $C_3H_8$ ), propene ( $C_3H_6$ ), and propyne ( $C_3H_4$ ). It is found that the mass percentage of propene in this gas mixture is 50%. Upon burning this mixed gas in the excess amount of oxygen, the mass of  $CO_2$  produced from the combustion of propane is equal to that produced from the combustion of propyne. What is the mole fraction of propyne in this gas mixture?

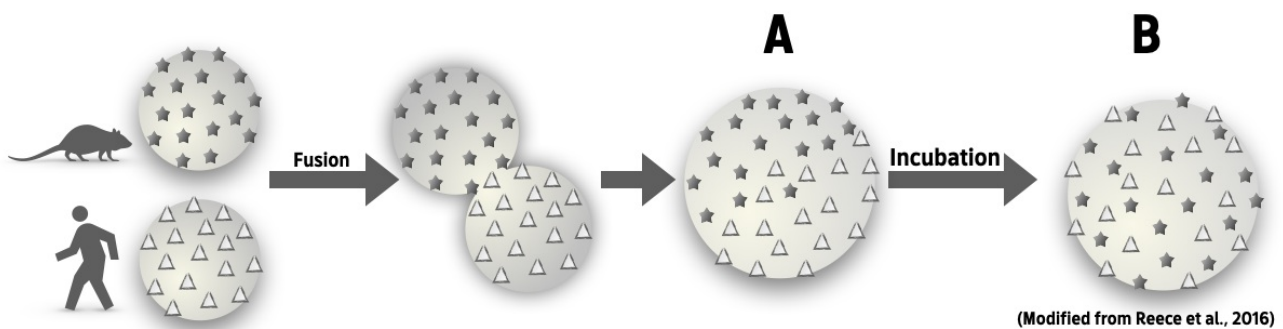
- A. 0.10
- B. 0.25
- C. 0.50
- D. 0.75



20. A series of sulfate samples is to be analyzed by precipitation as  $\text{BaSO}_4$ . If it is known that the sulfate content in these samples ranges between 20% and 55% by mass, what minimum sample mass should be taken to ensure that the precipitate mass no smaller than 0.200 g is produced?

- A. 0.150 g
- B. 0.200 g
- C. 0.220 g
- D. 0.412 g

21. Scientists labeled membrane proteins (proteins that exist in the plasma membrane) of a mouse cell and a human cell with two different markers. Two cells were fused forming a hybrid cell. Initially, proteins on the hybrid cell's surface were observed as state A. Normally, after incubating the cell at 37 °C for 1 hour, proteins from different sources would disperse throughout the surface of the cell as in state B.

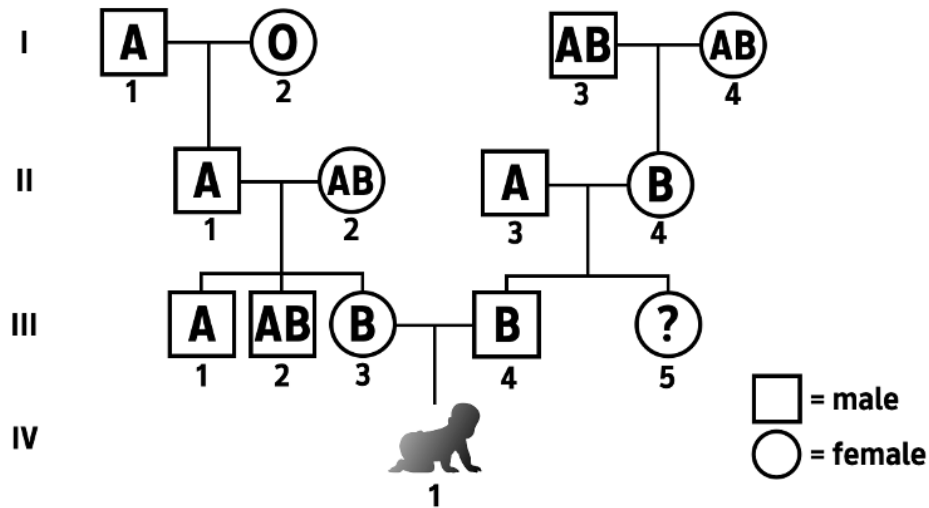


However, if the cell took 2 hours to transform from state A to state B, which of the following could be the reason(s)?

- I. Cell membrane possessed a greater unsaturated-to-saturated phospholipids ratio.
- II. The incubation temperature was done at 18 °C.

- A. I only
- B. II only
- C. I and II
- D. neither I nor II

22. The pedigree below illustrates the ABO blood type inheritance of two lineages.

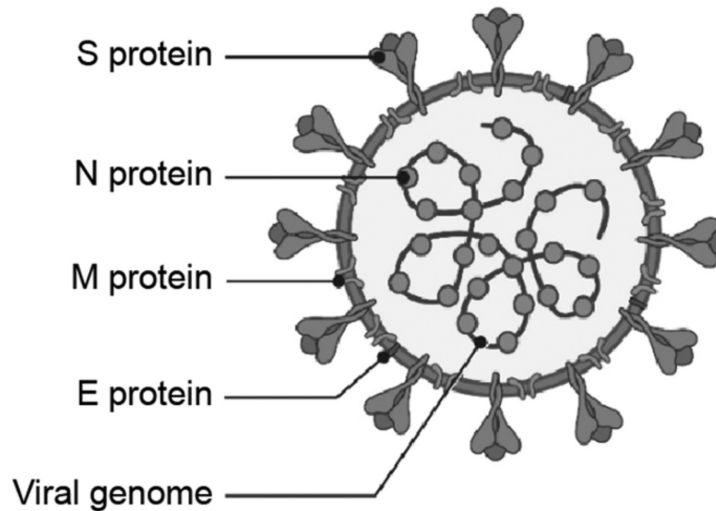


Which statements are true according to the pedigree?

- I. The baby IV-1 cannot be heterozygote.
- II. The probability of III-5 to be a B-type is 0.5.
- III. The genotype of II-1 can either be homozygous or heterozygous.
- IV. There is a chance for a child of III-1 and an AB-type woman to be B-type.

- A. I and II
- B. II and III
- C. III and IV
- D. II and IV

23. The following figure shows the structure of a coronavirus.



(Modified from <https://www.biophysics.org/blog/coronavirus-structure-vaccine-and-therapy-development>)

Which of the following statements is **incorrect**?

- A. Chemical analysis should reveal carbohydrate as a component of the coronavirus.
- B. Treatment of the coronavirus with ethanol should destroy lipid-rich envelope and denature the viral proteins, rendering the virus non-infectious.
- C. The N protein is expected to have a net negative charge.
- D. The E and M proteins are expected to have hydrophobic amino acids on the surfaces that face the lipid-rich envelope.



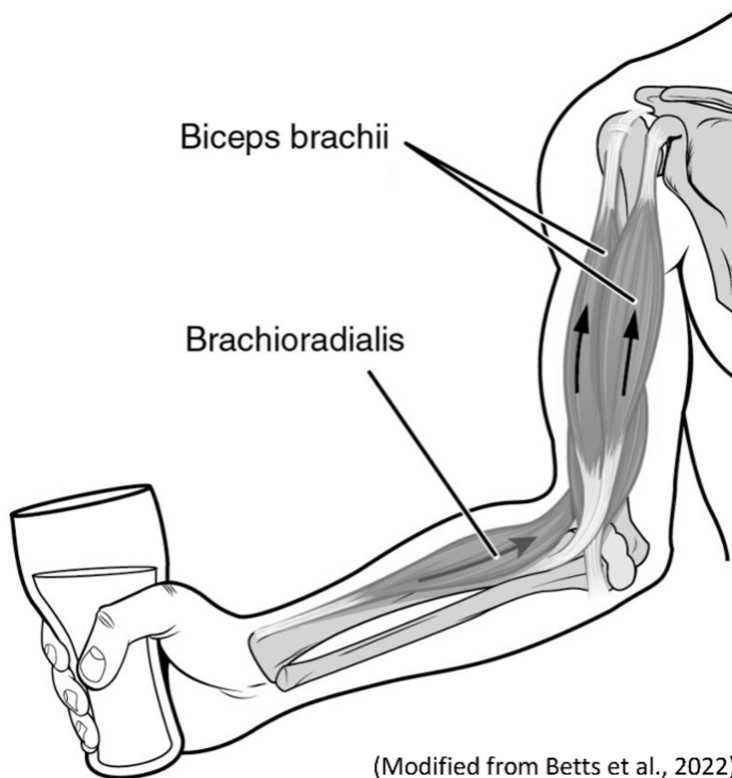
Points: 30

Time: 3 Hours

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24. A person is sick from the COVID-19 virus. What kind of immunity does this person receive from the sickness and then retain after recovery?
- A. Active immunity, innate immunity
  - B. Active immunity, acquired immunity
  - C. Passive immunity, innate immunity
  - D. Passive immunity, acquired immunity

25. The figure below shows the biceps brachii, which is a muscle that flexes the lower arm. The arrow indicates the tension force acting on the lower arm bone.



(Modified from Betts et al., 2022)

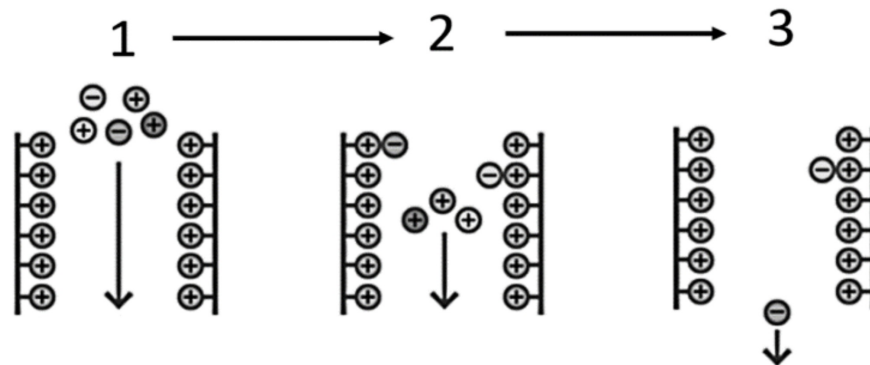
Consider the following statements:

- I. Biceps brachii can be voluntarily controlled.
- II. The muscle cell of the biceps brachii must have a striated appearance with multiple nuclei.
- III. The neurotransmitter released by the motor neurons involved in contraction of biceps brachii is glutamate.

Which statement(s) (I-III) is/are correct?

- A. I only
- B. II only
- C. I and II
- D. I and III

26. This diagram illustrates the principle of anion exchange chromatography. The column contains immobilized cationic surfaces (step 1) that can bind negatively charged molecules (step 2). After adding an elution buffer, these negatively charged molecules are released from the column (step 3).



(Modified from <https://theory.labster.com/iexchromatography/>)

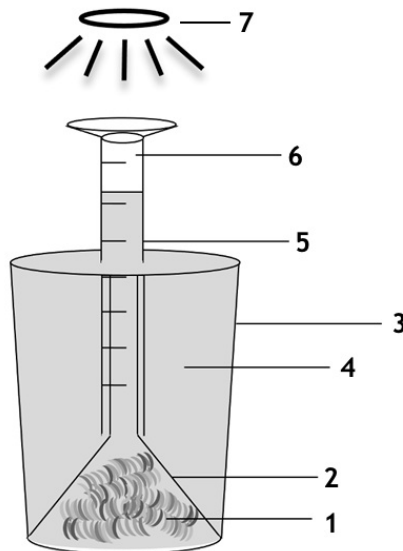
There are four test tubes containing the components listed in the table. Each test tube is incubated at an appropriate temperature and pH 7.0 for 1 hour before loading into an anion exchange chromatography column.

Test tube	Component
A	DNA + DNase
B	Tripeptide (Arg-Lys-Asp) + Exopeptidase
C	Ribonucleotide + Nucleosidase
D	Maltose + Maltase

After adding the elution buffer in step 3, which of the following molecules are expected to be eluted?

- A. Test tube A: Nucleosides
- B. Test tube B: Arg, Lys, and Asp
- C. Test tube C: Ribonucleotide
- D. Test tube D: Glucose and galactose

27. Two *Hydrilla* branches (1) are placed inside an upturned funnel (2) in a beaker (3) containing pond water (4) with added  $\text{NaHCO}_3$ . The end of the funnel is covered with a measuring cylinder (5) in which air (6) was trapped. A light bulb (7) is used as a light source.



Consider the following statements:

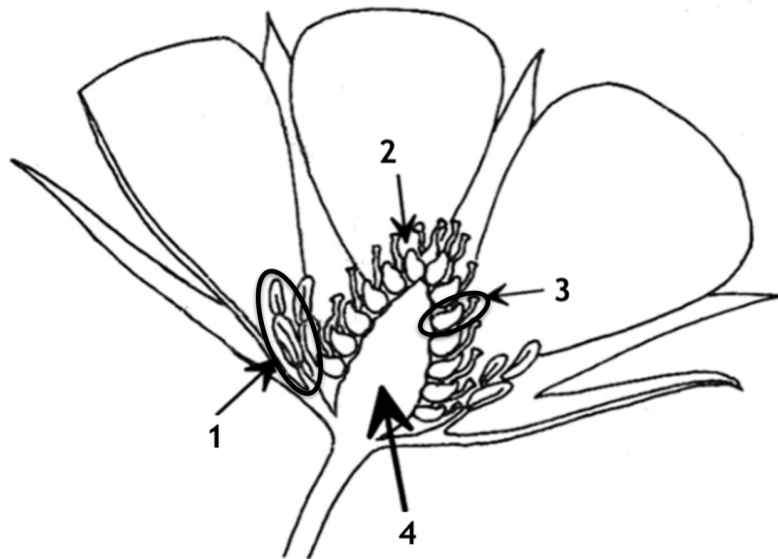
- I. If more  $\text{NaHCO}_3$  is added to the water, more bubbles will be observed.
- II. If the light is changed from white to blue light at the same intensity, more bubbles will be observed.
- III. If the light is changed from white to green light at the same intensity, more bubbles will be observed.
- IV. After three hours of the experiment, the air inside the cylinder is mostly carbon dioxide.

Which statements (I-IV) are correct?

- A. I only
- B. I and II
- C. II and III
- D. II and IV



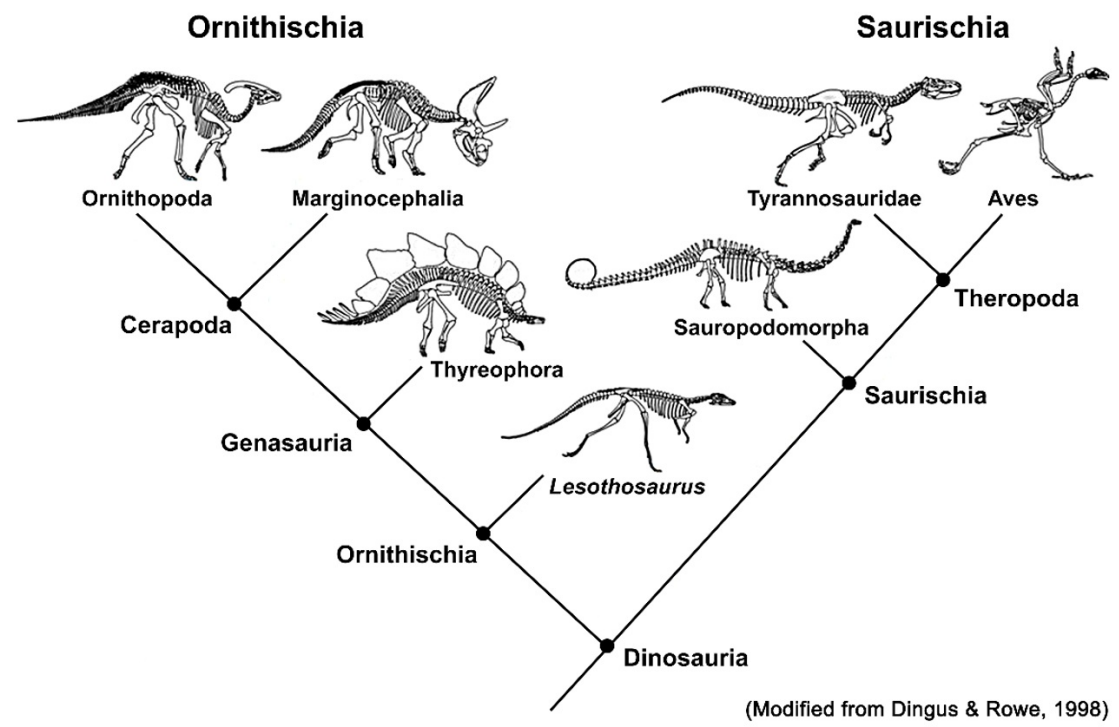
28. According to their development, type of flower, and the number of ovaries, fruits are classified into 3 types: simple fruit, aggregate fruit, and multiple fruit. If the flower shown in the diagram is fertilized, which type of fruit will be developed? (1: stamen, 2: carpel, 3: pistil, 4: receptacle)



(Modified from <https://fruit.umn.edu/content/flowers-to-fruit>)

- A. A simple fruit
- B. An aggregate fruit
- C. A multiple fruit
- D. A fruit with many seeds

29. Most of the dinosaurs are members of two lineages, namely Ornithischia and Saurischia. Ornithischia includes the bird-hipped dinosaurs, while Saurischia includes the lizard-hipped dinosaurs. The cladogram illustrates the relationships of these lineages. Modern birds were apparently descended from the saurischians; however, they possess hips similar to those of the relatively unrelated ornithischians.

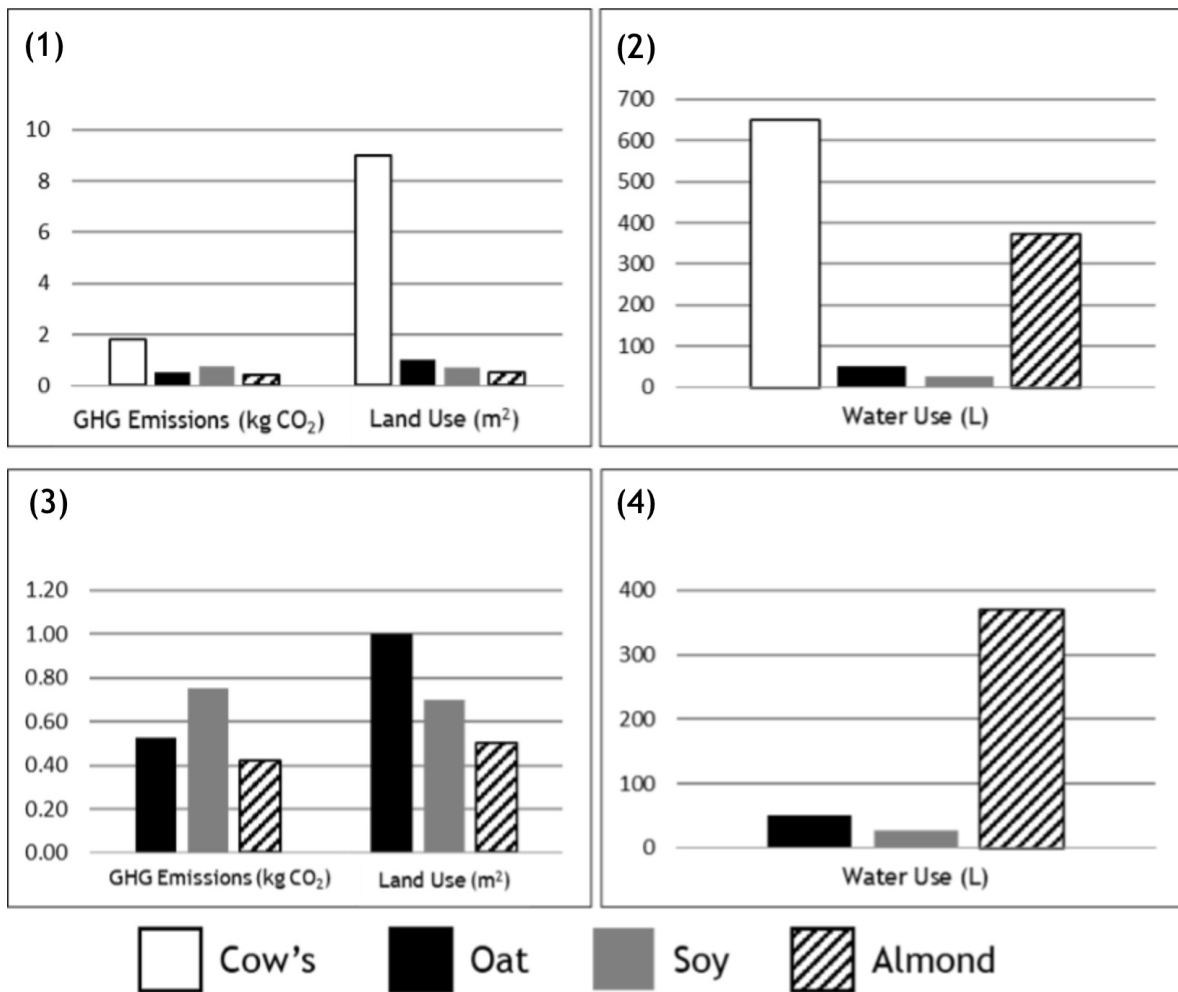


Which correctly explains this phenomenon?

- A. Adaptive radiation of the modern birds
- B. Convergent evolution with the ornithischians
- C. Divergent evolution with the ornithischians
- D. Descent with modification from a common ancestor of the saurischians

30. One of the suggested solutions to reduce greenhouse gas (GHG) emissions and climate change for a more sustainable future is to find alternatives in our diets, such as switching to plant-based milk instead of cow's milk. But are they really more environmentally friendly? Growing the crops and the production processes of these goods are not without their impacts. The environmental resources that are required for, and the GHG emissions that result from, production are important considerations. The following graphs show GHG emissions (kg CO<sub>2</sub>), land use (m<sup>2</sup>) and water use (L) per one liter of milk product.

- Graphs: (1) GHG emissions and land use of all milk products  
 (2) Water use of all milk products  
 (3) GHG emissions and land use of plant-based milk products  
 (4) Water use of plant-based milk products



The width of the bars is not relevant in the analysis of the question.

Consider the proposed plant-based milk products' suitability as alternatives to cow's milk. Which of the following statements are supported by the data?

- I. All of the proposed plant-based milk products are reasonable alternatives to cow's milk.
  - II. Considering all factors, soy milk is the best alternative to cow's milk.
  - III. Almond milk is the worst alternative to cow's milk overall.
  - IV. Compared to oat milk, cow's milk is worse for the environment in terms of land use than it is in terms of water use.
  - V. Almond milk's water requirements make it unviable as an alternative to cow's milk.
  - VI. Oat milk is not the best alternative to cow's milk for any given factor.
- 
- A. I, II, and IV
  - B. I, III, and VI
  - C. II, III, and IV
  - D. II, V, and VI