

NSMQ 2017 PAST QUESTIONS

With answers and worked solutions

NSMQ 2017 PAST QUESTIONS

WITH ANSWERS AND WORKED SOLUTIONS

Past contest questions with answers, worked solutions and speed tactics

47 questions • 4 contest papers • answers and worked solutions

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Spotted an error? Tell us in the app (Profile → About) so the next edition can fix it. Questions were transcribed from broadcasts and checked, but transcription mistakes can remain.

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HOW TO USE THIS BOOK

The **Contest Archive** gives every contest with its schools on record, round by round, with the answer, the working and a speed tip right after each question. Cover the answer with a card, try the question, then slide the card down.

The **Try Contests** are practice papers with no answers on the page. Sit one like the real thing, write your score in the boxes, then mark yourself with the **Try Contest Keys** at the back (each paper prints the page of its key). A reference such as **R2.14** means Round 2, question 14.

For every miss, read the working and the *Pitfall* line, then retry the question a day later.

Some solutions list only the answer. Where the stored working did not match the answer, we left the working out rather than print something misleading.

THE NSMQ FORMAT

- Each contest has three schools of two contestants, over five rounds.
- **Round 1 (Fundamentals):** every school answers four questions each in Biology, Chemistry, Physics and Mathematics; an unanswered question can pass to the other schools as a bonus.
- **Round 2 (Speed Race):** applied questions go to all three schools at once and schools ring a bell to answer.
- **Round 3 (Problem of the Day):** each school solves one 10-point problem; marks are given for each section of the worked solution.
- **Round 4 (True or False):** a correct answer earns 2 points and a wrong answer costs 1; a statement may be declined.
- **Round 5 (Riddles):** clues are read one at a time. A correct answer on clue 1 earns 5 points, on clue 2 earns 4, and on clue 3 or later earns 3.
- Stages: preliminaries, one-eighth, quarter-final, semi-final and the grand finale.

PART I: CONTEST ARCHIVE

3 contests · 29 questions

Every contest with its schools on record, round by round. Each question is followed by its answer, the working, a speed tip and the trap to avoid.

ONE-EIGHTH

2 contests

One-Eighth Contest 1: Sekondi College vs St. James Seminary SHS vs Anlo SHS

2017-06-17 • 5 questions

ROUND 4 (TRUE/FALSE)

R4.1

For a given surface, the maximum kinetic energy of a photoelectron ejected by a photon of frequency $2F$ is twice the maximum kinetic energy of a photoelectron ejected by a photon of frequency F .

ANSWER False. Using $K_{\max} = hf - \phi$ shows that doubling the photon frequency adds $2hF$ but subtracts the same ϕ , so you do not get exactly twice the kinetic energy except in the unphysical case $\phi = 0$.

R4.2

If a photon of wavelength λ ejects photoelectrons from a surface, it is possible that a photon of wavelength 2λ does not eject any photoelectrons from the same surface.

ANSWER True. Doubling the wavelength halves the photon energy; if that reduced energy falls below the material's work function, no photoelectrons are emitted.

ROUND 5 (RIDDLES)

R5.1 CHEMISTRY

1. I am one of the several characteristic properties of an element.
2. Unlike another property I know, I possess both positive and negative values. Who am I?

ANSWER Electron affinity

SPEED Electron affinity is the common elemental property with positive or negative values.

PITFALL *Confusing electron affinity with electronegativity, which never takes negative values.*

R5.2 MATHEMATICS

1. I am basically a sequence of statements.
2. I lead to a conclusion or result.
3. I am a process of logical reasoning.
4. My primary aim is to establish a theorem. Who am I?

ANSWER Proof

The question outlines the defining features of a mathematical proof: a logical sequence of statements aimed at establishing a theorem, so the answer is 'proof'.

SPEED All clues point toward the structure used to establish mathematical truth: a proof.

PITFALL *Confusing a 'proof' with an 'argument' or 'example', which do not establish general theorems.*

R5.3 PHYSICS

1. I occur only when change occurs.
2. I am an inductive phenomenon.
3. I produce electromagnetic fields.
4. I am the principle underlying the operation of a transformer. Who am I?

ANSWER Electromagnetic induction

Electromagnetic induction is the process by which a changing magnetic flux in a conductor induces an electromotive force, the fundamental principle behind transformer operation.

SPEED Transformers operate via changing magnetic flux: Faraday's law of induction.

PITFALL *Confusing electromagnetic induction with electromagnetism or with induced currents specifically, instead of the general phenomenon.*

One-Eighth Contest 2: St. Hubert Min. Seminary SHS vs Zebilla SHS vs Chemu SHS

2017-06-20 • 11 questions

ROUND 1 (FUNDAMENTALS)

R1.1 CHEMISTRY

State the type of forces that we should expect in solid glucose.

ANSWER Hydrogen bonding and van der Waals forces.

- (1) Glucose has molecular formula $C_6H_{12}O_6$ and each molecule contains several hydroxyl ($-OH$) groups.
- (2) The $-OH$ groups make each molecule both a hydrogen-bond donor and acceptor, so strong intermolecular hydrogen bonding occurs in the solid.
- (3) Besides hydrogen bonds, neutral molecular solids show van der Waals interactions (London dispersion and dipole interactions) between molecules.
- (4) Therefore the main forces present in solid glucose are hydrogen bonding and van der Waals forces.

SPEED Recall that glucose is a molecular solid with many $-OH$ groups, so hydrogen bonding dominates.

PITFALL Assuming ionic or metallic bonding because glucose is a solid, rather than recognizing it as a molecular solid with intermolecular forces.

R1.2 PHYSICS

What is the time in which a steady torque of $50 \text{ N} \cdot \text{m}$ can stop a rotating object of angular momentum $5.0 \times 10^2 \text{ J s}$?

ANSWER $t = \frac{L}{\tau} = 10 \text{ s}$

- (1) Identify the given values: angular momentum $L = 5.0 \times 10^2 \text{ J s}$ and steady torque $\tau = 50 \text{ N} \cdot \text{m}$.
- (2) Use the angular impulse-momentum theorem $\Delta L = \tau t$, which gives $t = \frac{\Delta L}{\tau}$.
- (3) Since we want to stop the object, set $\Delta L = L$ and compute $t = \frac{5.0 \times 10^2}{50} = 10 \text{ s}$.

SPEED For stopping time: time = angular momentum divided by applied torque.

PITFALL Forgetting that the torque must act opposite to the angular momentum to bring the object to rest, leading to sign confusion or unnecessary negative values.

R1.3 PHYSICS

Find the magnitude of the torque which increases the angular momentum of an object from 2 J s to 12 J s in 5 s .

ANSWER $\tau = \frac{\Delta L}{t} = 2 \text{ N m}$

(1) Calculate the change in angular momentum: $\Delta L = L_f - L_i = 12 \text{ J s} - 2 \text{ J s} = 10 \text{ J s}$.

(2) Recall the definition of torque as the rate of change of angular momentum: $\tau = \frac{\Delta L}{\Delta t}$.

(3) Substitute $\Delta L = 10 \text{ J s}$ and $\Delta t = 5 \text{ s}$ into the formula: $\tau = \frac{10 \text{ J s}}{5 \text{ s}} = 2 \text{ N m}$.

SPEED Change in momentum divided by time gives torque directly.

PITFALL Forgetting that torque equals the change in angular momentum divided by the time interval, not the final angular momentum divided by time.

R1.4 CHEMISTRY

Phosgene (COCl_2) reacts slowly with water to give carbonic acid and HCl . Write a balanced equation for the reaction.

ANSWER $\text{COCl}_2 + 2\text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 + 2\text{HCl}$

- (1) Identify phosgene as an acid chloride with formula COCl_2 .
- (2) Recognize that hydrolysis replaces each Cl with an OH from water, producing HCl for each substitution.
- (3) Write the products: replacing two Cl atoms by two OH groups gives H_2CO_3 (carbonic acid) and 2 HCl .
- (4) Count and balance all atoms: $1 \text{ C}, 2 \text{ Cl} \rightarrow 2 \text{ HCl}, 2 \text{ H}_2\text{O}$ provide 2 OH , yielding H_2CO_3 , so the equation is balanced.

SPEED Recognize substitution of both Cl atoms by OH from water, producing 2 HCl .

PITFALL Forgetting that two moles of water are required to supply both the hydrogen and oxygen atoms needed to form carbonic acid and two moles of HCl .

R1.5 PHYSICS

Using the same preamble, what is the frequency of a photon that ejects an electron of kinetic energy $6.4 \times 10^{-20} \text{ J}$?

ANSWER $6.5 \times 10^{14} \text{ Hz}$

- (1) Recall the photoelectric equation: $K_{\max} = hf - \phi$, where $\phi = hf_0$ is the work-function energy and f_0 is the threshold frequency.
- (2) Substitute $\phi = hf_0$ into the equation to get $K_{\max} = h(f - f_0)$, so $f = f_0 + \frac{K_{\max}}{h}$.
- (3) Use the given threshold frequency $f_0 = 5.5 \times 10^{14} \text{ Hz}$ (from the preamble) and $K_{\max} = 6.4 \times 10^{-20} \text{ J}$, and Planck's constant $h = 6.63 \times 10^{-34} \text{ J} \cdot \text{s}$.

(4) Compute the extra frequency $\Delta f = \frac{6.4 \times 10^{-20}}{6.63 \times 10^{-34}} \approx 9.65 \times 10^{13} \text{ Hz}$, then add to f_0 : $f = 5.5 \times 10^{14} + 9.65 \times 10^{13} \approx 6.5 \times 10^{14} \text{ Hz}$.

SPEED Add the extra KE to the work function-equivalent energy and divide by Planck's constant.

PITFALL Forgetting to include or correctly use the work function from the preamble, leading to using KE alone to compute the frequency.

ROUND 2 (SPEED RACE)

R2.1 PHYSICS

Find the radius of a charged metal sphere of charge $50 \mu\text{C}$ and potential 9 kV .

ANSWER 50 m

(1) Write down the formula for the potential of a charged conducting sphere: $V = \frac{kQ}{r}$.

(2) Rearrange to solve for the radius: $r = \frac{kQ}{V}$.

(3) Substitute the given values: $k = 9.0 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$, $Q = 50 \times 10^{-6} \text{ C}$, $V = 9.0 \times 10^3 \text{ V}$, so $r = \frac{9.0 \times 10^9 \times 50 \times 10^{-6}}{9.0 \times 10^3} = 50 \text{ m}$.

SPEED Use $V = kQ/r$. Rearranging gives $r = kQ/V$.

PITFALL Forgetting to convert microcoulombs to coulombs or kilovolts to volts, leading to an incorrect radius.

R2.2 PHYSICS

What is the time constant of an RC circuit with $R = 10 \Omega$ and $C = 20 \mu\text{F}$?

ANSWER 200 μs

(1) Write the formula for the time constant: $\tau = RC$.

(2) Convert capacitance from microfarads to farads: $C = 20 \mu\text{F} = 20 \times 10^{-6} \text{ F}$.

(3) Substitute $R = 10 \Omega$ and $C = 20 \times 10^{-6} \text{ F}$ into $\tau = RC$ and calculate: $\tau = 10 \times 20 \times 10^{-6} = 200 \times 10^{-6} \text{ s} = 200 \mu\text{s}$.

SPEED Time constant = RC . Multiply directly.

PITFALL Forgetting to convert microfarads (μF) to farads before multiplying.

R2.3 PHYSICS

Determine the change in kinetic energy of a 5 kg object whose momentum changes from 12 to $2 \text{ N}\cdot\text{s}$.

ANSWER -14 J

(1) Compute initial kinetic energy K_i using $p_i = 12 \text{ N}\cdot\text{s}$: $K_i = \frac{12^2}{2 \times 5} = \frac{144}{10} = 14.4 \text{ J}$.

(2) Compute final kinetic energy K_f using $p_f = 2 \text{ N}\cdot\text{s}$: $K_f = \frac{2^2}{2 \times 5} = \frac{4}{10} = 0.4 \text{ J}$.

(3) Compute change in kinetic energy: $\Delta K = K_f - K_i = 0.4 \text{ J} - 14.4 \text{ J} = -14 \text{ J}$.

SPEED Use $K = p^2/2m$ for each, then subtract final minus initial.

PITFALL Forgetting that kinetic energy depends on the square of momentum, causing students to subtract momenta before squaring instead of computing KE_{initial} and KE_{final} separately.

R2.4 CHEMISTRY

Given equal concentrations ($0.036 \text{ mol dm}^{-3}$) of NH_3 , NH_4^+ , and Cl^- , identify the type of solution.

ANSWER A buffer solution.

(1) Identify the species present: NH_3 (weak base), NH_4^+ (conjugate acid), and Cl^- (spectator ion)

(2) Observe that $[\text{NH}_3] = [\text{NH}_4^+] = 0.036 \text{ M}$

(3) Conclude that equal concentrations of a weak base and its conjugate acid form a buffer solution

SPEED Weak base plus conjugate acid always indicates a buffer.

PITFALL Assuming that the presence of Cl^- automatically implies a strong acid solution and overlooking the $\text{NH}_3/\text{NH}_4^+$ conjugate pair that creates the buffer.

R2.5 CHEMISTRY

Determine whether the redox reaction $\text{MnO}_4^- + 3\text{Fe}^{2+} + 2\text{H}_2\text{O} \rightarrow \text{MnO}_2 + 3\text{Fe}^{3+} + 4\text{OH}^-$ is possible, given electrode potentials 0.59 V and 0.77 V .

ANSWER Not feasible; net EMF is negative.

(1) Reduction half-reaction: $\text{MnO}_4^- + 2\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{MnO}_2 + 4\text{OH}^-$ with $E_{\text{red}} = 0.59 \text{ V}$ (given).

(2) Other half-reaction (given): $\text{Fe}^{3+} + \text{e}^- \rightarrow \text{Fe}^{2+}$ has $E^\circ = 0.77 \text{ V}$, so oxidation $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^-$ has $E_{\text{ox}} = -0.77 \text{ V}$.

(3) Net cell EMF is $E_{\text{cell}} = E_{\text{red}} + E_{\text{ox}} = 0.59 - 0.77 = -0.18 \text{ V}$.

(4) E_{cell} is negative, so the reaction is not feasible under the given conditions.

SPEED Subtract cathode-anode potentials. Negative EMF means reaction is not spontaneous.

PITFALL Incorrectly assigning which half-reaction is oxidation vs. reduction, leading to reversing the wrong electrode potential.

ROUND 3 (PROBLEM OF THE DAY)

R3.1 CHEMISTRY

Write balanced equations for the oxidation of Fe^{2+} to Fe^{3+} by MnO_4^- under acidic and basic conditions, showing half-reactions. Then determine under which condition the oxidation is possible.

ANSWER Oxidation is possible under acidic conditions only.

(1) Acidic half-reactions: reduction $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$, oxidation $Fe^{2+} \rightarrow Fe^{3+} + e^-$.
 Net: $5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$.

(2) Basic half-reactions: reduction $MnO_4^- + e^- \rightarrow MnO_4^{2-}$, oxidation $Fe^{2+} \rightarrow Fe^{3+} + e^-$. Net: $Fe^{2+} + MnO_4^- \rightarrow Fe^{3+} + MnO_4^{2-}$.

(3) Compare standard potentials: $E^\circ(MnO_4^-/Mn^{2+}) = +1.51\text{ V}$ and $E^\circ(Fe^{3+}/Fe^{2+}) = +0.77\text{ V}$, so $E_{cell} = 1.51 - 0.77 = +0.74\text{ V}$ (spontaneous in acid).

(4) In basic medium $E^\circ(MnO_4^-/MnO_4^{2-}) = +0.56\text{ V}$ so $E_{cell} = 0.56 - 0.77 = -0.21\text{ V}$ (non-spontaneous).

Hence oxidation is possible only in acidic conditions.

SPEED Compare electrode potentials: MnO_4^-/MnO_2 under acid has higher potential, making Fe^{2+} oxidation favorable.

PITFALL Forgetting that MnO_4^- is a weaker oxidizing agent in basic medium and assuming the same Mn reduction product (Mn^{2+}) instead of MnO_2 .

QUARTER-FINAL

1 contests

Quarter-final Contest 1: St. Hubert Min.Seminary SHS vs Nifa SHS vs St. Thomas Aquinas SHS

2017-06-24 • 13 questions

ROUND 3 (PROBLEM OF THE DAY)

R3.1 CHEMISTRY

A metal reacts with excess mineral acid according to the equation: $M(s) + 2H^+(aq) \rightarrow M^{2+}(aq) + H_2(g)$. Calculate the atomic mass of the metal if 2.0 g of the metal produces 900 cm³ of H₂ at 27°C and 100 kPa. Assume molar volume of a gas at STP is 22.4 dm³. Give your answer to one decimal place.

ANSWER 54.7 g

(1) Convert the gas volume to STP: $V_{STP} = 900 \text{ cm}^3 \times \frac{273 \text{ K}}{300 \text{ K}} = 819 \text{ cm}^3 = 0.819 \text{ dm}^3$.

(2) Moles of H₂: $n = \frac{0.819 \text{ dm}^3}{22.4 \text{ dm}^3 \text{ mol}^{-1}} = 0.03656 \text{ mol}$.

(3) The equation shows 1 mol of M gives 1 mol of H₂, so $n(M) = 0.03656 \text{ mol}$.

(4) Atomic mass = $\frac{2.0 \text{ g}}{0.03656 \text{ mol}} \approx 54.7 \text{ g mol}^{-1}$.

SPEED Convert gas volume to STP using Charles's law, compare with 22,400 cm³ per mole H₂, then proportion with 2 g of metal.

PITFALL Using the STP molar volume (22.4 dm³) directly without first converting the given temperature and pressure to STP conditions.

ROUND 4 (TRUE/FALSE)

R4.1

The first ionization energy of oxygen is higher than that of nitrogen.

ANSWER False. Nitrogen's half-filled p₃ subshell is more stable than oxygen's p₄, so nitrogen has a higher first ionization energy and the statement is false.

R4.2

The first ionization energy of aluminum is lower than that of magnesium.

ANSWER True. Because the added 3p electron in Al occupies a higher-energy, more shielded orbital than Mg's 3s electrons, it is easier to remove, giving Al a lower first ionization energy than Mg.

R4.3

If a tuning fork and string produce the same frequency, no beats are heard.

ANSWER True. Beats only occur when there is a nonzero frequency difference between two sources, so identical frequencies produce no amplitude modulation or beats.

R4.4

If beat frequency increases when string tension is increased, the fork has lower frequency.

ANSWER False. Raising the string's tension increases its frequency, so a bigger beat frequency shows the fork's frequency is higher, making the statement false.

R4.5

If beat frequency decreases when string tension is decreased, the fork has lower frequency.

ANSWER True. Reducing tension lowers the string's frequency, and the observed drop in beat rate shows the string frequency has moved closer to a lower fork frequency, confirming the fork's frequency is lower.

R4.6

The carbon-carbon double bond is shorter than the carbon-carbon single bond.

ANSWER True. A double bond has a higher bond order than a single bond, which increases electron density between the nuclei and pulls them closer together, resulting in a shorter bond.

R4.7

The carbon-nitrogen double bond is polar.

ANSWER True. Nitrogen's higher electronegativity relative to carbon causes unequal sharing of electrons in the C=N bond, creating a dipole.

R4.8

The hybridization of nitrogen in methylamine is sp^2 .

ANSWER False (it is sp^3). Methylamine's nitrogen has three sigma bonds and one lone pair, giving a steric number of 4 and thus sp^3 rather than sp^2 hybridization.

R4.9

In the Schrödinger model of hydrogen, the ground-state electron orbits the proton in a circular orbit of Bohr radius.

ANSWER False. In the Schrödinger model, the electron in hydrogen is described by a 1s orbital probability cloud rather than a fixed circular orbit, even though the most probable distance equals the Bohr radius.

R4.10

In the Schrödinger model of hydrogen, the most probable radial distance of the ground-state electron is the Bohr radius.

ANSWER True. The radial probability density for the hydrogen 1s orbital peaks at $r=a_0$, so the most probable distance of the ground-state electron is indeed the Bohr radius.

ROUND 5 (RIDDLES)**R5.1 PHYSICS**

1. I am a property of a material.
2. I have the same dimension and SI unit as pressure.
3. I am the stress at the peak of a stress-strain curve.
4. For ductile materials, I occur before fracture. Who am I?

ANSWER Ultimate tensile strength

Ultimate tensile strength is defined as the maximum engineering stress attained on the stress-strain curve before necking occurs, making it the peak stress value for ductile materials.

SPEED Peak stress on stress-strain curve matches definition.

PITFALL *Confusing ultimate tensile strength with yield strength or fracture strength*

R5.2 CHEMISTRY

1. I was born in the country of pyramids.
2. I am manufactured on industrial scale in all industrialized nations.
3. I dissolve readily in water to give an alkaline solution used as a household cleaner and a precursor to fertilizers.
4. I contain one nitrogen atom covalently bonded to three hydrogen atoms. Who am I?

ANSWER NH_3 (Ammonia)

Ammonia was first identified in Egyptian ammonium chloride deposits and today is synthesized industrially via the Haber process, making NH_3 the correct answer.

SPEED Haber process began in Egypt historically; widespread production.

PITFALL *Confusing ammonia with other major industrial chemicals like sulfuric acid or nitric acid based on vague clues.*

PART II: TRY CONTESTS

1 practice papers

Contests whose schools were not recorded, set as practice papers. Sit each one like the real thing: one round at a time, against the clock, answers closed. Write your score in the boxes, then mark yourself with the keys in the next part.

TRY CONTESTS: ONE-EIGHTH

One-Eighth Try Contest 1: mixed questions

18 questions from other broadcasts and the printed compilation • Answers: page 10

Your score R1: ____ / 3 R2: ____ / 1 R3: ____ / 1 R4: ____ / 12 R5: ____ / 1

ROUND 1 (FUNDAMENTALS)

R1.1 PHYSICS

What is the time in which a steady torque of 50 N m can stop a rotating object of angular momentum $5.0 \times 10^2 \text{ J s}$?

R1.2 BIOLOGY

Define an inferior (epigynous) ovary.

R1.3 BIOLOGY

Define a staminate flower.

ROUND 2 (SPEED RACE)

R2.1 PHYSICS

What is the time constant of an RC circuit with $R = 10 \text{ } \Omega$ and $C = 20 \text{ } \mu\text{F}$?

ROUND 3 (PROBLEM OF THE DAY)

R3.1 CHEMISTRY

A metal reacts with excess mineral acid according to the equation: $\text{M(s)} + 2\text{H(aq)} \rightarrow \text{M}^{2+}(\text{aq}) + \text{H}_2(\text{g})$. Calculate the atomic mass of the metal if 2.0 g of the metal produces 900 cm³ of H₂ at 27 °C and 100 kPa. Assume molar volume of a gas at STP is 22.4 dm³. Give your answer to one decimal place.

ROUND 4 (TRUE/FALSE)

R4.1

If a nursing mother is not producing enough milk, then her hormonal system is probably deficient in thyroxine.

R4.2

If a nursing mother is not producing enough milk, then her hormonal system is probably deficient in prolactin.

R4.3

ATP is used only in animal cells and not in plant cells.

R4.4

ATP is needed for chemical, mechanical, and transport processes in organisms.

R4.5

ATP carries energy between degradative pathways and synthetic pathways.

R4.6

The diagonals are perpendicular and bisect each other.

R4.7

There are two axes of symmetry and the diagonals are congruent.

R4.8

Opposite angles are congruent and the adjacent angles are supplementary.

R4.9

If blood solute concentration rises, less water is reabsorbed in the kidney tubules.

R4.10

If blood solute concentration rises, more salt is reabsorbed in the kidney tubules.

R4.11

The compound statement P and Q is true if either P or Q is true.

R4.12

The implication 'if P then Q' is true if both P and Q are false.

ROUND 5 (RIDDLES)

R5.1 BIOLOGY

1. I am the main anchoring and food-storing structure of many plants that grows deep into the soil.
2. I usually form a single large primary axis with smaller branches arising from it.
3. The first three letters of my name mean to strike gently with a light blow or blows, or a valve and spout used to regulate fluid.
4. The last four letters refer to the embedded portion of a tooth, nail, or hair. Who am I?

PART III: TRY CONTEST KEYS

Answers and working for the Try Contests, in the same order. A reference such as R2.14 means Round 2, question 14.

KEYS: ONE-EIGHTH

Key — One-Eighth Try Contest 1: mixed questions

ROUND 1 (FUNDAMENTALS)

R1.1 $t = L = 10 \text{ s}$

R1.2 An ovary located below the other floral parts.

R1.3 A flower that contains only the male reproductive organs.

SPEED Stamen = male organ. Staminate = male-only flower.

ROUND 2 (SPEED RACE)

R2.1 $200 \mu\text{s}$

SPEED Time constant = RC. Multiply directly.

ROUND 3 (PROBLEM OF THE DAY)

R3.1 55.5 g

SPEED Convert gas volume to STP using Charles's law, compare with $22,400 \text{ cm}^3$ per mole H_2 , then proportion with 2 g of metal.

ROUND 4 (TRUE/FALSE)

R4.1 **False.** Milk production depends primarily on prolactin, not thyroxine.

R4.2 **True.** Prolactin directly stimulates milk production; deficiency reduces output.

R4.3 **False.** Recall ATP is universal energy currency in all living cells.

R4.4 **True.** ATP powers all cellular work.

R4.5 **True.** ATP couples catabolism to anabolism.

R4.6 **True.** These are properties of a rhombus/kite depending on context.

R4.7 **False.** Congruent diagonals occur in rectangles, but not necessarily with two axes of symmetry.

R4.8 **True.** These are defining properties of parallelograms.

R4.9 **True.** High solute triggers decreased water reabsorption without ADH.

R4.10 **False.** Salt handling does not increase automatically with solute concentration.

R4.11 **False.** AND requires both true.

R4.12 **True.** False antecedent makes implication true.

ROUND 5 (RIDDLES)

R5.1 Taproot

Tap = strike lightly; root = embedded part; combined they form a biological term.

SPEED Tap = strike lightly; root = embedded part; combined they form a biological term.

APPENDIX: SPEED SHORTCUT INDEX

The full cards, with worked examples, are in the companion volume *NSMQ Speed Shortcuts* and in the Fomla app.

Mathematics

GP common ratio for terms $x + a$, $x + b$, $x + c$
 Sum-zero and square-chain shortcuts
 Area bounded by a line and both axes
 Circle through three points — sum-of-squares reduction
 n^{th} derivative of $\frac{1}{x}$
 Derivative shortcut for $\frac{ax+b}{cx+d}$ and $\frac{ax^n+b}{cx^n+d}$
 Stationary point of $\frac{ax^n+b}{cx^n+d}$ (contest shortcut)
 Shift rule: from $f(x+a)$ to $f(x+b)$
 Reciprocal log-sum
 Conjugate limit: $\frac{\sqrt{x+a}-\sqrt{a}}{x}$
 Pythagorean triples from one side
 Recurring decimals $\rightarrow$ fractions
 Perfect square test for quadratics
 n^{th} term from a quadratic sum $S_n = An^2 + Bn$
 AP common difference from any two terms
 GP common ratio from two terms
 Middle terms of a 4-term AP and a 4-term GP
 Angle between the hands of a clock
 Parabolic-segment area for symmetric parabola
 Even-number-of-successes closed form (Bernoulli trials)
 Recognise ${}_N P_r$ as a consecutive-product to find N
 Focus-Directrix $\rightarrow$ Immediate Parabola
 Simpson's exact shortcut (polynomials up to cubic)

Physics

Escape speed versus orbital speed
 Elastic-modulus relations (Y , K , η , σ)
 Molecular speed ratios (most probable, mean, r.m.s.)
 Radius and cyclotron frequency in a uniform magnetic field
 Contact force between two pushed blocks
 Lami's theorem
 Two masses over a pulley (Atwood machine)
 Speed of sound — gas & temperature scaling

Solve $X^Y = 1$ — finite-case checklist
 Two-dice sum counts (triangular rule)
 Inverse of a Möbius map
 Max/min of $A \cos x + B \sin x$ (amplitude trick)
 Perpendicular bisector from origin — one-line formula
 Repeated-root derivative condition
 Shift-to-multiplication for $A * B = A + B + AB$
 Factor consecutive powers / base-change cancellation
 Same-base exponential / log swap
 Sine between planar vectors via determinant
 Frustum shortcut for volumes from linear functions
 Quick prime search: use $6k \pm 1$ + trial division
 Tangents to an incircle — perimeter shortcut
 ± 1 quick-root tests (sum / alternating sum)
 Constant term by exponent matching in binomial expansion
 Cover-up method for partial fractions (distinct linear factors)
 Discriminant trick — range of a linear over a quadratic
 Monic cubic quick factor test ($r = p \cdot q$)
 Odd integer as difference of consecutive squares
 Quadratic from a conjugate irrational root
 Quadratic from three equally spaced values
 Solve $x^x = a^b$ by prime-power spotting
 Symmetric power identities: $x \pm 1/x$ and higher powers

Adiabatic small- Δ linearisation (first-order)
 Perfectly Inelastic (stick) collision — final speed and KE loss
 Equal-mass elastic collision KE split
 Prism apex 60° : minimum-deviation shortcut
 Use surface g to get GM
 Poiseuille r^4 scaling (flow comparisons)
 Impedance-triangle inversion for series RLC
 Elevator-scale ratio rule

Two equal-amplitude waves — resultant amplitude & intensity

Conducting sphere one-step relations ($V \leftrightarrow Q \leftrightarrow \sigma \leftrightarrow E$)

Lens shortcuts: image distance from f and magnification

Pivot at the unknown (torque problems)

Compton scattering — photon-energy form

Relativistic de Broglie from Compton + Lorentz

Small thermal expansion $\rightarrow$ quick pendulum frequency change

Chemistry

Avogadro's number as a fraction

Formal charge

Hybridisation by fast count: $H = \frac{V+M-C+A}{2}$

Hückel's rule (quick aromaticity check)

Radius-ratio $\rightarrow$ Coordination number (no calc)

van't Hoff factor for partial dissociation

Trouton's rule (ΔH_{vap} quick estimate)

Limiting reagent — divide moles by coefficient

Units of the rate constant (overall order)

Polyprotic midpoint equivalents ($k - 0.5$ rule)

Molarity from solution density and mass % (1-line)

Rapid oxide-stoichiometry scan (compute Ar from %O)

Degree of Unsaturation (DBE)

Quick O_2 for combustion of $C_xH_yO_z$

pH of salt (conjugate base) of a weak acid — quick formula

Graham's law — rates, times and meeting point

$K_{\text{sp}} \rightarrow$ molar solubility for M_pX_q

Biology

Distinct gametes — quick count

Species–Area quick estimate (species–area relation)

Surface-area-to-volume (SA:V) rule — quantitative

Chromosome & chromatid counting (G1/S/G2/mitosis/meiosis I/II)

Gene-order from pairwise recombination (smallest-pair + additivity)

Angiosperm reproduction counting rule

KEEP PRACTISING

Scan the code for timed drills, a Speed Race and a daily problem in the Fomla app.



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