

NUST NET practice: chemistry (30 MCQs)

This practice set has 30 original multiple-choice questions written in the style of the chemistry section of the NUST Entry Test (NET). NUST publishes a topic list for the NET chemistry section based on the FSc Part 1 and Part 2 courses. Check the current list on the NUST admissions site before your test, because the new national-curriculum FSc books have moved some topics between chapters. The questions cover the mole concept and stoichiometry, atomic structure, gases, liquids and solids, chemical bonding, thermochemistry, chemical equilibrium, acids and bases, reaction kinetics, electrochemistry, periodic trends, s- and p-block elements, basic organic chemistry (hydrocarbons, alcohols, aldehydes and ketones, carboxylic acids) and macromolecules. The questions are grouped by topic in FSc order, not by difficulty. Some need two steps of reasoning (for example Questions 2, 13, 16 and 21). After the questions you will find an answer key and a worked solution for every question.

How the paper is marked and how to use this set

- Every question has exactly one correct option. Each correct answer earns one mark [1].
- NUST has not used negative marking in recent NET series, so never leave a question blank. If you are unsure, remove the options you know are wrong and then choose from what is left. Check the instructions for your own test series in case the rules change.
- Timing: aim for about 1 minute per chemistry question. Try this set in **30 minutes** without a calculator. The numbers are chosen so the arithmetic can be done by hand, as it must be in the real test.
- Use A_r : H = 1, C = 12, N = 14, O = 16, Cu = 63.5. Avogadro constant $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$. 1 F = 96 500 C mol^{-1} .

Questions

1. How many oxygen atoms are in 8.8 g of carbon dioxide, CO_2 ? [1]

- A. 1.20×10^{23}
- B. 2.41×10^{23}
- C. 4.82×10^{23}
- D. 1.20×10^{24}

2. 4 g of hydrogen gas and 16 g of oxygen gas are mixed and sparked. The reaction goes until one reactant is used up: $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{l})$. What mass of water forms? [1]

- A. 36 g
- B. 20 g
- C. 18 g
- D. 9 g

3. Which set of quantum numbers is **not** allowed for an electron in an atom? [1]

- A. $n = 2, l = 2, m = 0$

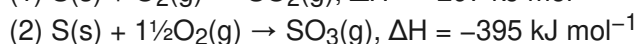
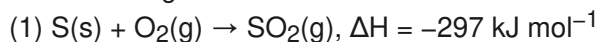
- B. $n = 3, l = 2, m = -2$
 - C. $n = 2, l = 1, m = +1$
 - D. $n = 4, l = 0, m = 0$
4. What is the ground-state electronic configuration of chromium ($Z = 24$)? [1]
- A. $[\text{Ar}] 3d^4 4s^2$
 - B. $[\text{Ar}] 3d^6$
 - C. $[\text{Ar}] 3d^5 4s^2$
 - D. $[\text{Ar}] 3d^5 4s^1$
5. A sample of gas takes up 300 cm^3 at 27°C and 1 atm. What is its volume at 127°C and 2 atm? [1]
- A. 600 cm^3
 - B. 400 cm^3
 - C. 200 cm^3
 - D. 150 cm^3
6. Under the same conditions, which gas diffuses four times as fast as oxygen, O_2 ? [1]
- A. H_2
 - B. He
 - C. CH_4
 - D. N_2
7. Which liquid has the highest vapour pressure at 25°C ? [1]
- A. Water, H_2O
 - B. Ethanol, $\text{C}_2\text{H}_5\text{OH}$
 - C. Ethanoic acid, CH_3COOH
 - D. Diethyl ether, $(\text{C}_2\text{H}_5)_2\text{O}$
8. In the sodium chloride crystal lattice, how many chloride ions are nearest neighbours of each sodium ion? [1]
- A. 4
 - B. 6
 - C. 8
 - D. 12
9. Using VSEPR theory, what are the shape and approximate bond angle of the ammonia molecule, NH_3 ? [1]
- A. Trigonal pyramidal, about 107°
 - B. Trigonal planar, 120°
 - C. Tetrahedral, 109.5°
 - D. Bent (V-shaped), about 104.5°
10. Which molecule has polar bonds but a zero overall dipole moment? [1]

- A. H_2O
- B. NH_3
- C. BF_3
- D. CHCl_3

11. What is the hybridisation of each carbon atom in ethyne, $\text{HC}\equiv\text{CH}$? [1]

- A. sp^3
- B. sp^2
- C. sp^3d
- D. sp

12. You are given:



What is ΔH for $\text{SO}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{SO}_3(\text{g})$? [1]

- A. -692 kJ mol^{-1}
- B. -98 kJ mol^{-1}
- C. $+98 \text{ kJ mol}^{-1}$
- D. -395 kJ mol^{-1}

13. The enthalpy of neutralisation of a strong acid by a strong base is $-57.3 \text{ kJ mol}^{-1}$. How much heat is released when 100 cm^3 of 1.0 mol dm^{-3} HCl is mixed with 50 cm^3 of 1.0 mol dm^{-3} NaOH? [1]

- A. 5.73 kJ
- B. 2.87 kJ
- C. 57.3 kJ
- D. 8.60 kJ

14. What are the units of K_c for the reaction $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$? [1]

- A. $\text{mol}^{-2} \text{ dm}^6$
- B. $\text{mol}^2 \text{ dm}^{-6}$
- C. mol dm^{-3}
- D. No units

15. Methanol is made industrially by the equilibrium $\text{CO}(\text{g}) + 2\text{H}_2(\text{g}) \rightleftharpoons \text{CH}_3\text{OH}(\text{g}), \Delta\text{H} = -91 \text{ kJ mol}^{-1}$. Which change increases the amount of CH_3OH at equilibrium? [1]

- A. Raising the temperature
- B. Adding a catalyst
- C. Removing some of the hydrogen
- D. Increasing the total pressure

16. A 1.0 dm^3 flask at equilibrium contains 0.10 mol H_2 , 0.30 mol I_2 and 0.60 mol HI . The reaction is $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$. What is K_c ? [1]

- A. 20

- B. 0.083
- C. 12
- D. 48

17. What is the pH of a $0.005 \text{ mol dm}^{-3}$ solution of barium hydroxide, $\text{Ba}(\text{OH})_2$, at 25°C ? Assume it dissociates completely. [1]

- A. 12
- B. 2
- C. 11.7
- D. 13

18. Which mixture of aqueous solutions acts as a buffer? [1]

- A. HCl and NaCl
- B. NaOH and NaCl
- C. CH_3COOH and CH_3COONa
- D. HNO_3 and KNO_3

19. The rate equation for a reaction is $\text{rate} = k[\text{A}]^2[\text{B}]$. If [A] is doubled and [B] is halved at the same time, what happens to the rate? [1]

- A. It stays the same
- B. It doubles
- C. It becomes four times as great
- D. It halves

20. A first-order reaction has a half-life of 20 minutes. What fraction of the reactant is left after 60 minutes? [1]

- A. $1/3$
- B. $1/6$
- C. $1/4$
- D. $1/8$

21. The standard electrode potentials are $E^\circ(\text{Mg}^{2+}/\text{Mg}) = -2.37 \text{ V}$ and $E^\circ(\text{Ag}^+/\text{Ag}) = +0.80 \text{ V}$. What is the standard e.m.f. of a cell made from these two half-cells? [1]

- A. $+3.17 \text{ V}$
- B. -3.17 V
- C. $+3.97 \text{ V}$
- D. -1.57 V

22. A charge of 0.20 faraday is passed through aqueous copper(II) sulphate using inert electrodes. What mass of copper is deposited at the cathode? [1]

- A. 12.7 g
- B. 3.18 g

- C. 63.5 g
- D. 6.35 g

23. Going across Period 3 from sodium to chlorine, which property increases? [1]

- A. Atomic radius
- B. Metallic character
- C. Electronegativity
- D. Reducing power of the element

24. Which Group 2 sulphate is the least soluble in water? [1]

- A. MgSO_4
- B. BaSO_4
- C. CaSO_4
- D. BeSO_4

25. Which oxide is amphoteric? [1]

- A. SO_2
- B. MgO
- C. P_4O_{10}
- D. Al_2O_3

26. Propene reacts with hydrogen bromide. What is the main product? [1]

- A. 2-bromopropane
- B. 1-bromopropane
- C. 1,2-dibromopropane
- D. Propane

27. Which alcohol gives a ketone when it is warmed with acidified potassium dichromate(VI)? [1]

- A. Methanol
- B. Ethanol
- C. Propan-2-ol
- D. 2-methylpropan-2-ol

28. Which carbonyl compound gives a yellow precipitate of iodoform (CHI_3) when warmed with iodine and sodium hydroxide? [1]

- A. Methanal, HCHO
- B. Ethanal, CH_3CHO
- C. Propanal, $\text{CH}_3\text{CH}_2\text{CHO}$
- D. Benzaldehyde, $\text{C}_6\text{H}_5\text{CHO}$

29. Which acid is the strongest? [1]

- A. CCl_3COOH

- B. CH_3COOH
- C. CH_2ClCOOH
- D. CHCl_2COOH

30. Which pair of monomers is used to make nylon-6,6? [1]

- A. Ethane-1,2-diol and benzene-1,4-dicarboxylic acid
- B. Hexane-1,6-diamine and ethanedioic acid
- C. Phenol and methanal
- D. Hexane-1,6-diamine and hexanedioic acid

Answer key

Question	Answer	Question	Answer	Question
1	B	11	D	21
2	C	12	B	22
3	A	13	B	23
4	D	14	A	24
5	C	15	D	25
6	A	16	C	26
7	D	17	A	27
8	B	18	C	28
9	A	19	B	29
10	C	20	D	30

Question	Answer
1	A
2	D
3	C
4	B
5	D
6	A
7	C
8	B
9	A
10	D

Answer spread: A = 8, B = 7, C = 7, D = 8.

Worked solutions

1. **B.** $M(\text{CO}_2) = 12 + 2(16) = 44 \text{ g mol}^{-1}$.

Moles of $\text{CO}_2 = 8.8 \div 44 = 0.20 \text{ mol}$.

Each CO_2 molecule has 2 O atoms, so moles of O atoms = $2 \times 0.20 = 0.40 \text{ mol}$.

Number of O atoms = $0.40 \times 6.02 \times 10^{23} = 2.41 \times 10^{23}$.

Trap: option A (1.20×10^{23}) is the number of CO_2 molecules, not oxygen atoms.

2. **C.** Moles of $\text{H}_2 = 4 \div 2 = 2.0 \text{ mol}$. Moles of $\text{O}_2 = 16 \div 32 = 0.50 \text{ mol}$.

The equation needs 1 mol O_2 for every 2 mol H_2 . So 2.0 mol H_2 would need 1.0 mol O_2 , but only 0.50 mol is present. O_2 is the limiting reagent.

$0.50 \text{ mol O}_2 \rightarrow 2 \times 0.50 = 1.0 \text{ mol H}_2\text{O} = 1.0 \times 18 = 18 \text{ g}$.

Check: $16 \text{ g O}_2 + 2 \text{ g H}_2$ used = 18 g, and 2 g of H_2 is left over. Option B (20 g) wrongly assumes that all of both gases react.

3. **A.** The azimuthal quantum number l can take values from 0 to $(n - 1)$. When $n = 2$, l can only be 0 or 1, so $l = 2$ is not allowed. In B, C and D, l is less than n and m lies between $-l$ and $+l$, so they are all allowed.

4. **D.** The expected filling would give $[\text{Ar}] 3d^4 4s^2$. However, a half-filled d subshell ($3d^5$) is extra stable because of symmetry and exchange energy. One 4s electron therefore moves into 3d, giving $[\text{Ar}] 3d^5 4s^1$. Option C ($[\text{Ar}] 3d^5 4s^2$) has 25 electrons, so it is the configuration of manganese, not chromium. Copper is the other well-known exception: $[\text{Ar}] 3d^{10} 4s^1$.

5. **C.** Use the general gas equation, $P_1V_1/T_1 = P_2V_2/T_2$, with temperatures in kelvin.

$T_1 = 27 + 273 = 300 \text{ K}$; $T_2 = 127 + 273 = 400 \text{ K}$.

$V_2 = V_1 \times (P_1/P_2) \times (T_2/T_1) = 300 \times (1/2) \times (400/300) = 200 \text{ cm}^3$.

Doubling the pressure halves the volume, and heating from 300 K to 400 K multiplies it by 4/3.

6. **A.** Graham's law: $\text{rate} \propto 1/\sqrt{M}$, so $\text{rate}(\text{X})/\text{rate}(\text{O}_2) = \sqrt{M(\text{O}_2)/M(\text{X})}$.

$4 = \sqrt{(32/M(\text{X}))} \rightarrow 16 = 32/M(\text{X}) \rightarrow M(\text{X}) = 2 \text{ g mol}^{-1}$, which is H_2 .

For comparison, He ($M = 4$) diffuses $\sqrt{8} \approx 2.83$ times as fast as O_2 .

7. **D.** Vapour pressure is highest when the forces between molecules are weakest. Water, ethanol and ethanoic acid all form hydrogen bonds between their molecules. Diethyl ether has no O–H group, so its molecules cannot hydrogen-bond to each other. They are held only by weak dipole–dipole and London forces. Ether is the most volatile of the four: its boiling point is about 35°C .

8. **B.** NaCl has a face-centred cubic arrangement in which each Na^+ sits at the centre of an octahedron of six Cl^- ions, and each Cl^- is surrounded by six Na^+ . The coordination is 6:6. Caesium chloride, which has larger cations, shows 8:8 coordination (option C).

9. **A.** Nitrogen has 5 valence electrons. Three are used in N–H bonds and two form one lone pair, giving 4 electron pairs in total. These pairs point roughly towards the corners of a tetrahedron. A

lone pair repels more strongly than a bond pair, so the H–N–H angle closes from 109.5° to about 107°. Only the atoms are counted when naming the shape, so NH₃ is trigonal pyramidal.

10. C. Each B–F bond is polar because F is much more electronegative than B. BF₃ is trigonal planar with bond angles of 120°, so the three equal bond dipoles cancel and the resultant is zero. H₂O (bent) and NH₃ (pyramidal) are not symmetrical. CHCl₃ is tetrahedral but has one C–H bond and three C–Cl bonds. The bond dipoles are unequal, so they do not cancel (compare CCl₄, which is non-polar).

11. D. Each carbon in ethyne forms two σ bonds (one to H and one to the other C) and has no lone pairs. Two σ bonds need two hybrid orbitals, so the carbon is sp hybridised and linear (180°). The two unhybridised p orbitals on each carbon form the two π bonds of the triple bond.

12. B. Hess's law: the target equation is equation (2) minus equation (1).

Keep (2): S + 1½O₂ → SO₃, ΔH = –395

Reverse (1): SO₂ → S + O₂, ΔH = +297

Add them: SO₂ + ½O₂ → SO₃. The S cancels, and 1½O₂ – O₂ = ½O₂.

ΔH = –395 + 297 = –98 kJ mol^{–1}.

Option A (–692) adds the two values without reversing equation (1). Option C has the wrong sign.

13. B. Moles of HCl = 1.0 × 100/1000 = 0.10 mol. Moles of NaOH = 1.0 × 50/1000 = 0.050 mol. H⁺ + OH[–] → H₂O reacts 1:1, so NaOH is limiting and only 0.050 mol of water forms.

Heat released = 0.050 × 57.3 = 2.865 ≈ 2.87 kJ.

Option A (5.73 kJ) wrongly uses the moles of HCl, which is in excess.

14. A. K_c = [NH₃]² / ([N₂][H₂]³).

Units = (mol dm^{–3})² ÷ (mol dm^{–3})⁴ = (mol dm^{–3})^{–2} = mol^{–2} dm⁶.

Quick rule: power = (moles of gaseous products) – (moles of gaseous reactants) = 2 – 4 = –2.

15. D. There are 3 mol of gas on the left (1 CO + 2 H₂) and only 1 mol on the right. By Le Chatelier's principle, increasing the pressure shifts the equilibrium towards the side with fewer gas molecules, so more CH₃OH forms.

The forward reaction is exothermic (ΔH negative), so raising the temperature shifts the equilibrium in the endothermic (backward) direction and reduces the CH₃OH. Removing H₂ also shifts it to the left. A catalyst speeds up the forward and reverse reactions equally and does not change the equilibrium position.

16. C. The volume is 1.0 dm³, so the concentrations equal the numbers of moles.

K_c = [HI]² / ([H₂][I₂]) = (0.60)² / (0.10 × 0.30) = 0.36 / 0.030 = 12.

Moles of gas are equal on both sides, so K_c has no units and the volume would cancel even if it were not 1 dm³.

Option A (20) forgets to square [HI]: 0.60 / 0.030 = 20. Option B (0.083) turns the expression upside down: 0.030 / 0.36. Option D (48) doubles [HI] before squaring: (1.20)² / 0.030 = 48.

17. A. Ba(OH)₂ → Ba²⁺ + 2OH[–], so [OH[–]] = 2 × 0.005 = 0.010 mol dm^{–3}.

$$\text{pOH} = -\log(0.010) = 2.$$

At 25 °C, $\text{pH} + \text{pOH} = 14$, so $\text{pH} = 14 - 2 = 12$.

Option C (11.7) comes from forgetting that each formula unit releases two OH^- ions.

18. C. A buffer contains a weak acid and its conjugate base (or a weak base and its conjugate acid). Ethanoic acid is a weak acid, and ethanoate ions from CH_3COONa are its conjugate base. Added H^+ is removed by CH_3COO^- , and added OH^- is removed by CH_3COOH , so the pH hardly changes. The other options contain a strong acid or a strong base with its salt, which cannot resist changes in pH.

19. B. New rate = $k(2[\text{A}])^2(\frac{1}{2}[\text{B}]) = k \times 4[\text{A}]^2 \times \frac{1}{2}[\text{B}] = 2k[\text{A}]^2[\text{B}]$.

The rate becomes 2 times the original, so it doubles.

20. D. The half-life of a first-order reaction is constant. $60 \text{ min} \div 20 \text{ min} = 3$ half-lives.

Fraction left = $(\frac{1}{2})^3 = 1/8$, which is 12.5% of the starting amount.

21. A. The half-cell with the more positive E° (Ag^+/Ag) is the cathode, where reduction happens. Magnesium is the anode, where oxidation happens.

$$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}} = (+0.80) - (-2.37) = +3.17 \text{ V}.$$

A positive e.m.f. means the reaction $\text{Mg} + 2\text{Ag}^+ \rightarrow \text{Mg}^{2+} + 2\text{Ag}$ is spontaneous.

Traps: electrode potentials are *not* multiplied by the number in the balanced equation, so option C (+3.97 V, from $2 \times 0.80 + 2.37$) is wrong. Option D (−1.57 V) comes from adding the two values instead of subtracting. Option B has the cathode and anode the wrong way round.

22. D. Cathode reaction: $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$. One faraday is the charge on 1 mol of electrons.

$$0.20 \text{ F} = 0.20 \text{ mol e}^- \rightarrow 0.20 \div 2 = 0.10 \text{ mol Cu}.$$

$$\text{Mass} = 0.10 \times 63.5 = 6.35 \text{ g}.$$

Option A (12.7 g) forgets that each Cu^{2+} ion needs two electrons.

23. C. Across a period the nuclear charge increases, but the shielding from inner electrons stays almost the same. The outer electrons are pulled in more tightly. As a result, atomic radius decreases, metallic character decreases and the elements become weaker reducing agents (Na is a strong reducing agent; Cl_2 is an oxidising agent). Electronegativity increases from Na (about 0.9) to Cl (about 3.2).

24. B. The solubility of the Group 2 sulphates falls down the group. The lattice energy decreases only slightly, because the large sulphate ion dominates the ion spacing. The hydration energy of the cation falls much more steeply as the cation gets bigger. BeSO_4 and MgSO_4 are soluble, CaSO_4 is sparingly soluble and BaSO_4 is almost insoluble. This is why adding Ba^{2+} gives a white precipitate in the test for sulphate ions.

25. D. An amphoteric oxide reacts with both acids and bases. Aluminium oxide dissolves in acid to give Al^{3+} salts: $\text{Al}_2\text{O}_3 + 6\text{HCl} \rightarrow 2\text{AlCl}_3 + 3\text{H}_2\text{O}$. It also dissolves in hot concentrated alkali to give aluminates: $\text{Al}_2\text{O}_3 + 2\text{NaOH} + 3\text{H}_2\text{O} \rightarrow 2\text{NaAl}(\text{OH})_4$ (written in many FSc books as $\text{Al}_2\text{O}_3 +$

$2\text{NaOH} \rightarrow 2\text{NaAlO}_2 + \text{H}_2\text{O}$). MgO is basic, while SO_2 and P_4O_{10} are acidic.

26. A. This is electrophilic addition. By Markovnikov's rule, H adds to the carbon of the double bond that already has more hydrogen atoms (the CH_2 end). Br then adds to the middle carbon. The reason is that this route goes through the more stable secondary carbocation, $\text{CH}_3\text{C}^+\text{HCH}_3$. $\text{CH}_3\text{CH}=\text{CH}_2 + \text{HBr} \rightarrow \text{CH}_3\text{CHBrCH}_3$ (2-bromopropane).

Beyond FSc, for interest only: if peroxides are present, HBr adds the other way round and gives 1-bromopropane.

27. C. Secondary alcohols are oxidised to ketones: $(\text{CH}_3)_2\text{CHOH} + [\text{O}] \rightarrow (\text{CH}_3)_2\text{C}=\text{O} + \text{H}_2\text{O}$, giving propanone. Methanol and ethanol are primary alcohols and give aldehydes, which can be oxidised further to carboxylic acids. 2-methylpropan-2-ol is tertiary: it has no H on the carbon carrying the OH, so it is not oxidised under these conditions. The orange dichromate stays orange.

28. B. The iodoform test is positive for compounds that contain the $\text{CH}_3\text{CO}-$ group (or $\text{CH}_3\text{CH}(\text{OH})-$, which is first oxidised to it). Ethanal, CH_3CHO , is the only aldehyde with this group. Methanal has no methyl group. In propanal the carbonyl carbon is joined to CH_2 , not CH_3 . Benzaldehyde has no methyl group at all. The yellow solid formed is CHI_3 .

29. A. Chlorine atoms pull electron density away from the carboxylate group (a $-I$ effect). This spreads out the negative charge and stabilises the anion formed when the acid loses H^+ . The more Cl atoms there are on the α -carbon, the stronger the acid. The order is $\text{CCl}_3\text{COOH} > \text{CHCl}_2\text{COOH} > \text{CH}_2\text{ClCOOH} > \text{CH}_3\text{COOH}$, so trichloroethanoic acid is the strongest.

30. D. Nylon-6,6 is a condensation polyamide. Hexane-1,6-diamine, $\text{H}_2\text{N}(\text{CH}_2)_6\text{NH}_2$, and hexanedioic (adipic) acid, $\text{HOOC}(\text{CH}_2)_4\text{COOH}$, join through amide links ($-\text{CO}-\text{NH}-$) and lose water. Both monomers have six carbon atoms, which is where the name "6,6" comes from. Why the other pairs are wrong: A (a diol and a dicarboxylic acid) gives a polyester, Terylene, not a polyamide. B does give a polyamide, but ethanedioic acid has only two carbon atoms, so the product would not be nylon-6,6. C (phenol and methanal) gives the thermosetting resin Bakelite.

Tip for revision: list every question you got wrong under its topic heading. If two or more wrong answers fall under the same topic, go back to that FSc chapter before you try another practice set.