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Chemistry

Higher level

Paper 1A

16 May 2025

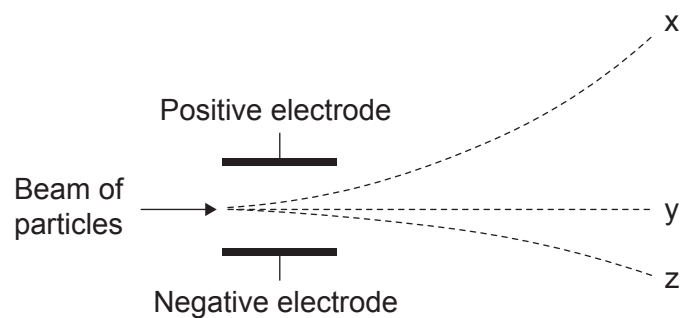
Zone A afternoon | **Zone B** afternoon | **Zone C** afternoon

2 hours [Paper 1A and Paper 1B]

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for paper 1A is **[40 marks]**.
- The maximum mark for paper 1A and paper 1B is **[75 marks]**.

1. The diagram below shows the behaviour of protons, neutrons and electrons in an electric field.



What is the correct identity of each particle?

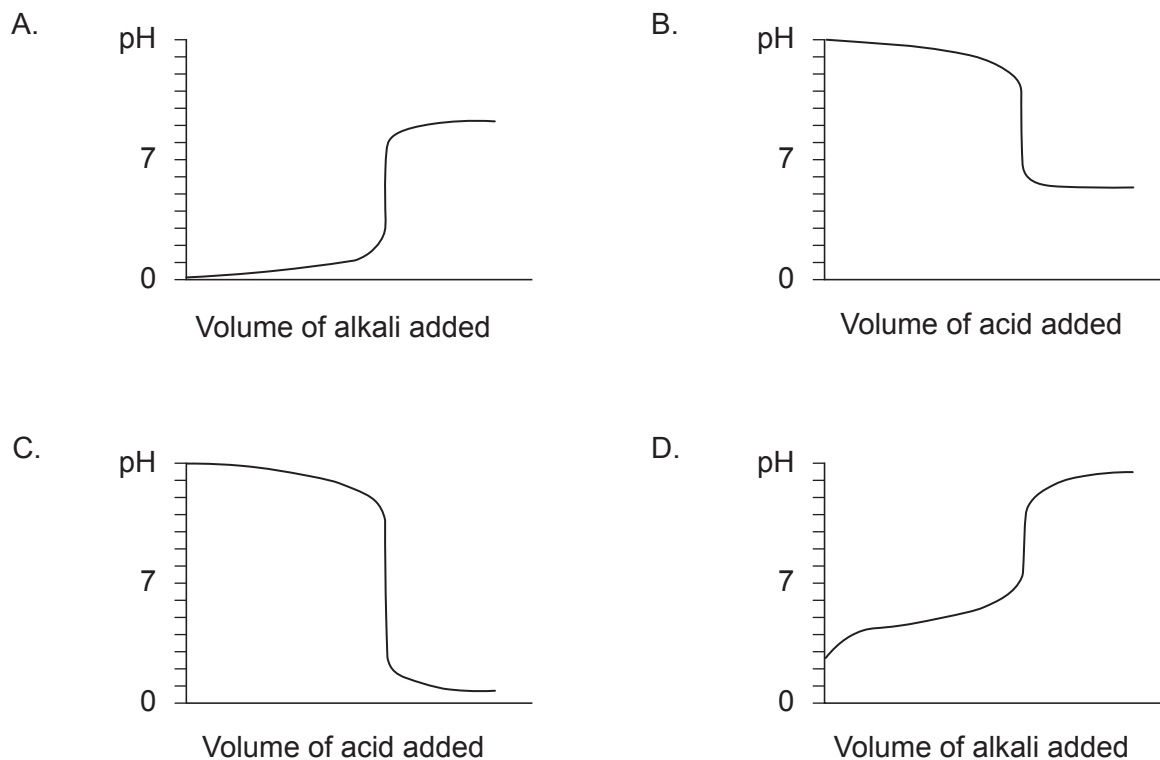
	Protons	Electrons	Neutrons
A.	y	z	x
B.	x	y	z
C.	z	x	y
D.	x	z	y

2. Which of the following species have the same number of outer electrons?
The letters **do not** represent symbols of elements.

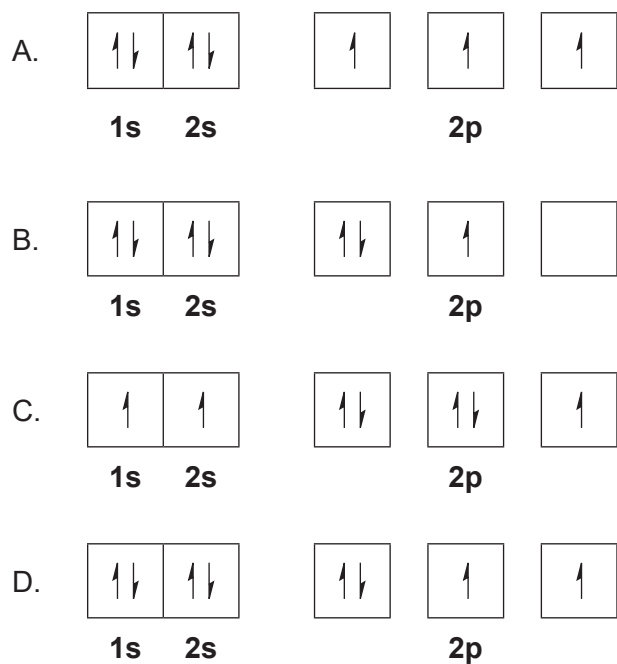


- A. X and Y
B. X and W
C. Z and Y
D. Z and W

3. Which chart shows the neutralization curve of a strong base with a strong acid?



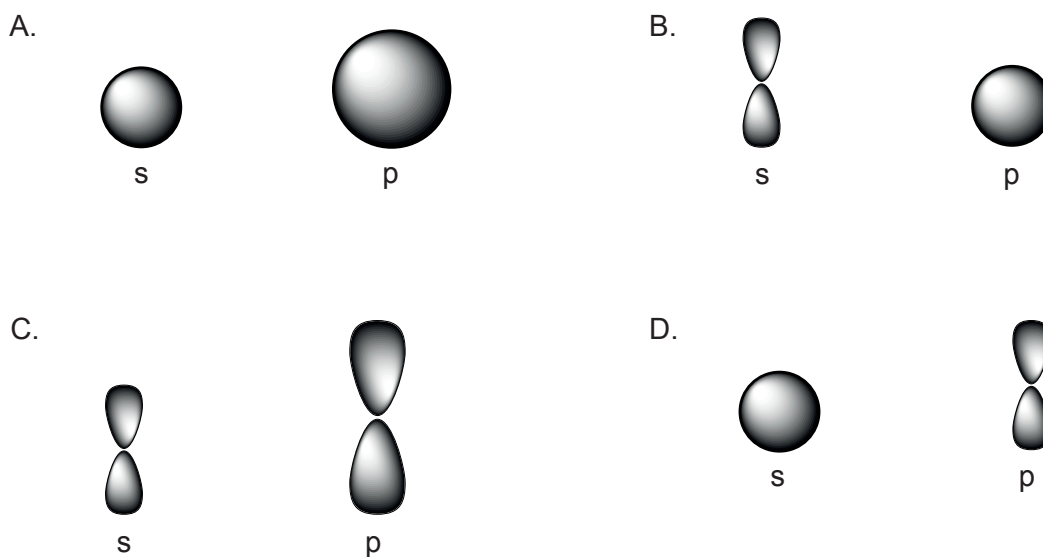
4. Which diagram shows the correct electron configuration of a nitrogen atom in the ground state?



5. Which row shows a gas that would deviate the least from ideal gas behaviour?

	Gas	Pressure	Temperature
A.	Phosphine, PH_3	Low	High
B.	Ammonia, NH_3	Low	High
C.	Phosphine, PH_3	High	Low
D.	Ammonia, NH_3	High	Low

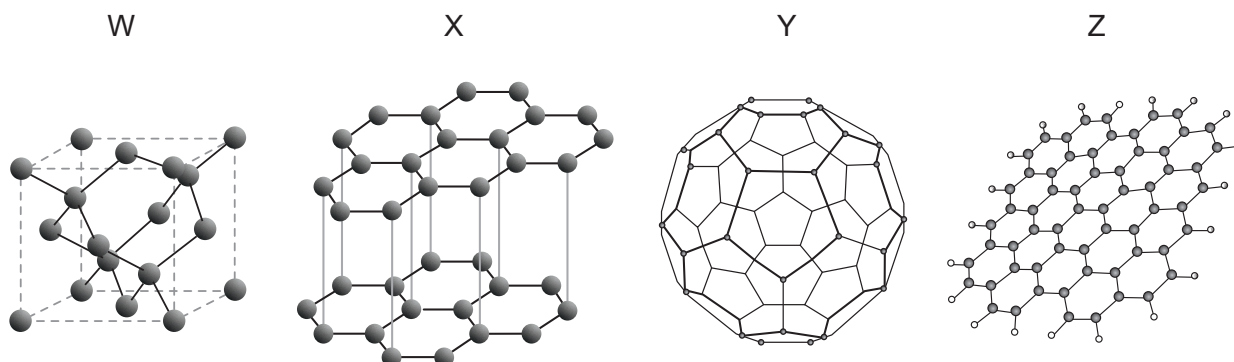
6. Which of the following correctly shows the shape of s and p orbitals?



7. Which row shows the correct formula and electron configuration of the species in calcium nitride?

	Formula	Electron configuration of the Ca species	Electron configuration of the N species
A.	Ca_2N_3	[Ar]	[Ne]
B.	Ca_2N_3	[Ar] $4s^2$	[He] $2s^2 2p^3$
C.	Ca_3N_2	[Ar] $4s^2$	[He] $2s^2 2p^3$
D.	Ca_3N_2	[Ar]	[Ne]

8. Diagrams of four stable allotropes of carbon are shown. Which row correctly identifies each structure?

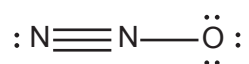


	Graphene	Fullerene	Graphite	Diamond
A.	Z	Y	X	W
B.	W	Z	Y	X
C.	X	W	Z	Y
D.	Y	X	W	Z

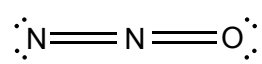
9. In which of the following molecules do all atoms obey the octet rule?

- I. NF_3
 II. BF_3
 III. PCl_3
- A. I and II only
 B. I and III only
 C. II and III only
 D. I, II and III

10. Nitrogen(I) oxide, N_2O , can be represented by two Lewis formulas.



Structure X



Structure Y

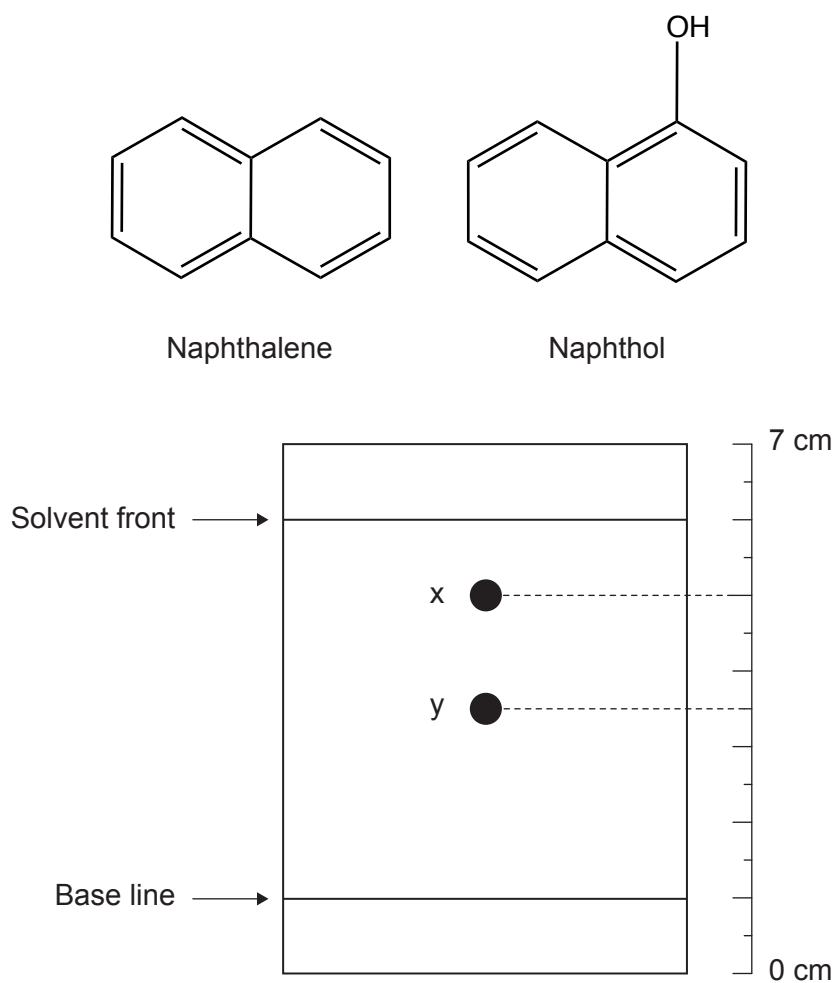
Which row correctly identifies the formal charges and the more stable structure?

	Structure X $:\text{N}\equiv\text{N}-\ddot{\text{O}}:$			Structure Y $\cdot\ddot{\text{N}}=\text{N}=\ddot{\text{O}}\cdot$			More stable
A.	0	+1	–1	–1	+1	0	X
B.	–1	+1	0	+1	0	–1	X
C.	0	+1	–1	–1	0	+1	Y
D.	–1	0	+1	0	+1	–1	Y

11. Which row puts these molecules in order of decreasing bond angle?

- A. NH_3 , H_2O , C_2H_4 , CH_4
- B. H_2O , C_2H_4 , CH_4 , NH_3
- C. C_2H_4 , CH_4 , NH_3 , H_2O
- D. CH_4 , NH_3 , H_2O , C_2H_4

12. The following thin-layer chromatogram was obtained from a mixture of naphthalene, $C_{10}H_8$, and naphthol, $C_{10}H_8O$. A polar silica was used as the stationary phase, and a non-polar hexane as the mobile phase.



What are the position and retardation factor (R_F) of naphthalene?

- A. y and 0.50
- B. y and 0.58
- C. x and 0.80
- D. x and 0.83

13. Kekulé suggested a structure of benzene with alternating single and double bonds. Which piece of evidence disproves this structure?
- Benzene has the formula C_6H_6 .
 - Benzene is an unsaturated molecule.
 - All C–C bonds have the same length.
 - Benzene can be hydrogenated.
14. Germanium has several stable oxidation states. Which row shows these species in order of increasing radius?
- Ge^{4+} , Ge^{2+} , Ge , Ge^{4-} .
 - Ge^{4-} , Ge^{4+} , Ge^{2+} , Ge .
 - Ge , Ge^{4-} , Ge^{4+} , Ge^{2+} .
 - Ge^{2+} , Ge , Ge^{4-} , Ge^{4+} .
15. Which statement explains the trend in first ionisation energy from sodium, Na, to chlorine, Cl?
- Nuclear charge increases.
 - Electronegativity decreases.
 - Atomic radius increases.
 - Shielding decreases.
16. Which elements would react with each other most vigorously?
- K(s) and $Br_2(g)$.
 - K(s) and $Cl_2(g)$.
 - Na(s) and $Br_2(g)$.
 - Na(s) and $Cl_2(g)$.

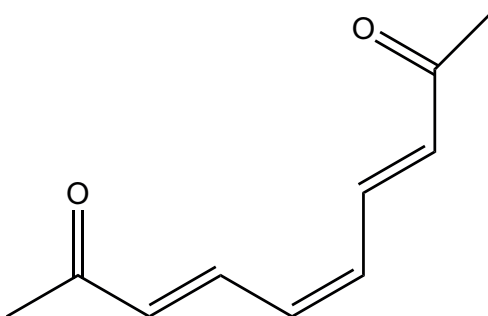
17. The volume of a container filled with a fixed amount of gas is increased by 100 % at constant temperature. How does this affect the pressure in a container? $pV = nRT$
- A. Pressure increases by 100 %
 - B. Pressure decreases by 100 %
 - C. Pressure increases by 50 %
 - D. Pressure decreases by 50 %
18. Which statement explains why transition elements have variable oxidation states?
- A. d-Electrons are delocalized.
 - B. All have a +2 oxidation state.
 - C. They can accept electron pairs from ligands.
 - D. Successive ionization energies are close in value.

19. Which oxygen-containing molecule has this low-resolution ^1H NMR spectrum?

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- A. Butanoic acid
- B. Ethyl ethanoate
- C. Methyl propanoate
- D. Butanone

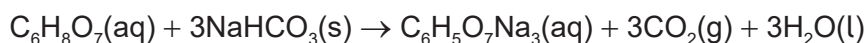
20. Consider this molecule, deca-3,5,7-triene-2,9-dione.



How many stereoisomers are possible for deca-3,5,7-triene-2,9-dione?

- A. 3
- B. 6
- C. 8
- D. 9
21. What is a disadvantage of using infrared (IR) spectroscopy as a technique?
- A. It cannot detect small atoms like H.
- B. It can only detect molar mass.
- C. It alters the chemical structure of the sample.
- D. It can only identify bonds, not their position.
22. Which equation correctly shows **both** enthalpy of formation, $\Delta H_f^\ominus$, of a compound and enthalpy of combustion, $\Delta H_c^\ominus$, of its elements?
- A. $\text{CO(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)}$
- B. $\frac{1}{2}\text{N}_2\text{(g)} + 1\frac{1}{2}\text{H}_2\text{(g)} \rightarrow \text{NH}_3\text{(g)}$
- C. $2\text{S(s)} + 3\text{O}_2\text{(g)} \rightarrow 2\text{SO}_3\text{(g)}$
- D. $\text{H}_2\text{(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{H}_2\text{O(l)}$

23. 0.050 mol of sodium hydrogencarbonate was added to 50 cm³ of 2.0 mol dm⁻³ solution of citric acid.

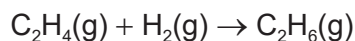


The initial temperature of the solution was 298 K and the final temperature was 297 K. What is the enthalpy of this reaction in kJ mol⁻¹? ($c_w = 4.18 \text{ J g}^{-1} \text{ K}^{-1}$, $Q = mc\Delta T$)

- A. +4.18
B. -4.18
C. +12.5
D. -12.5
24. The table shows enthalpy of combustion data for several substances.

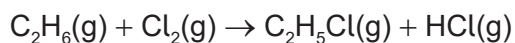
Substance	$\Delta H_c^\ominus$ (kJ mol ⁻¹)
C ₂ H ₆	-1561
C ₂ H ₄	-1411
H ₂	-286

Which expression would give the enthalpy for the following reaction?



- A. -1561 + 286 - 1411
B. -1411 - 286 + 1561
C. -1411 + 286 + 1561
D. -1561 - 286 - 1411
25. Which of the following reactions will have the largest positive change in entropy?
- A. $\text{CaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
B. $\text{CaO}(\text{s}) + \text{CO}_2(\text{g}) \rightarrow \text{CaCO}_3(\text{s})$
C. $\text{I}_2(\text{g}) + \text{H}_2(\text{g}) \rightarrow 2\text{HI}(\text{g})$
D. $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$

26. Chloroethane is produced by the reaction of ethane with chlorine.

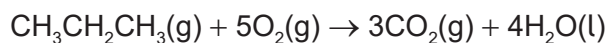


($\text{C}_2\text{H}_6 = 30.08 \text{ g mol}^{-1}$, $\text{Cl}_2 = 70.90 \text{ g mol}^{-1}$, $\text{C}_2\text{H}_5\text{Cl} = 64.52 \text{ g mol}^{-1}$, $\text{HCl} = 36.46 \text{ g mol}^{-1}$)

$$\% \text{ atom economy} = \frac{\text{molar mass of desired product}}{\text{molar mass of all reactants}} \times 100$$

What is the atom economy for this reaction?

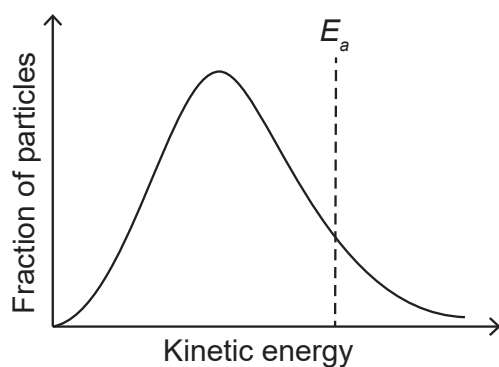
- A. 15.7 %
 - B. 46.6 %
 - C. 63.9 %
 - D. 99.9 %
27. 75 cm³ of propane was completely combusted in 400 cm³ of oxygen according to the following equation.



What is the volume of unreacted oxygen remaining at the original conditions?

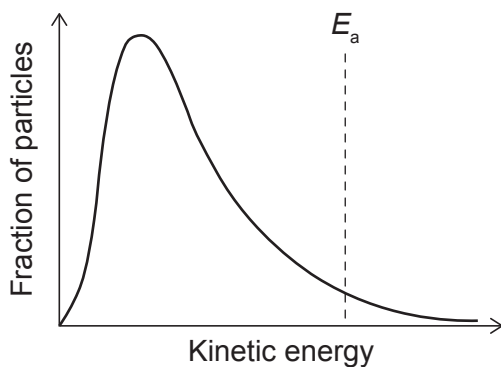
- A. 25 cm³.
- B. 50 cm³.
- C. 75 cm³.
- D. 150 cm³.

28. Consider the following Maxwell-Boltzmann distribution.

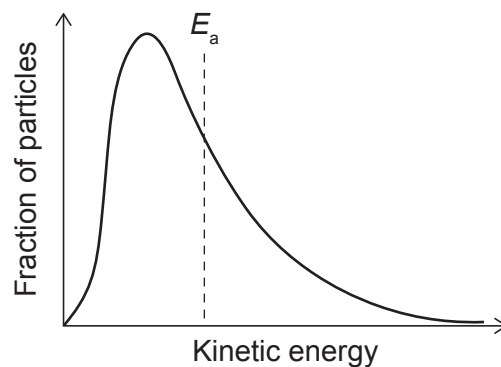


Which represents the distribution and value of activation energy at a lower temperature?

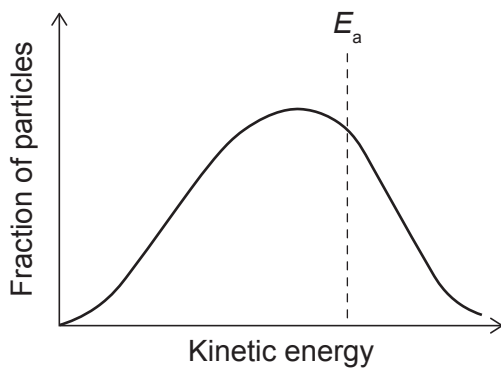
A.



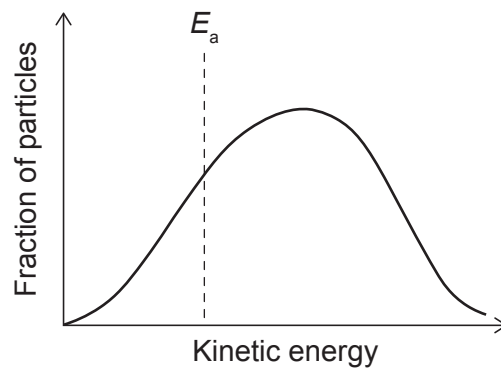
B.



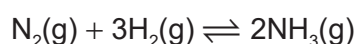
C.



D.



29. Consider the following system at equilibrium:



$$\Delta H_r^\ominus = -46 \text{ kJ mol}^{-1}$$

Which row correctly describes the initial effect of a change in pressure on the equilibrium position and the relationship between Q and K ?

	Change in pressure	Equilibrium shift	Relationship between Q and K
A.	decrease	to the left	$Q < K$
B.	increase	to the left	$Q > K$
C.	decrease	to the right	$Q > K$
D.	increase	to the right	$Q < K$

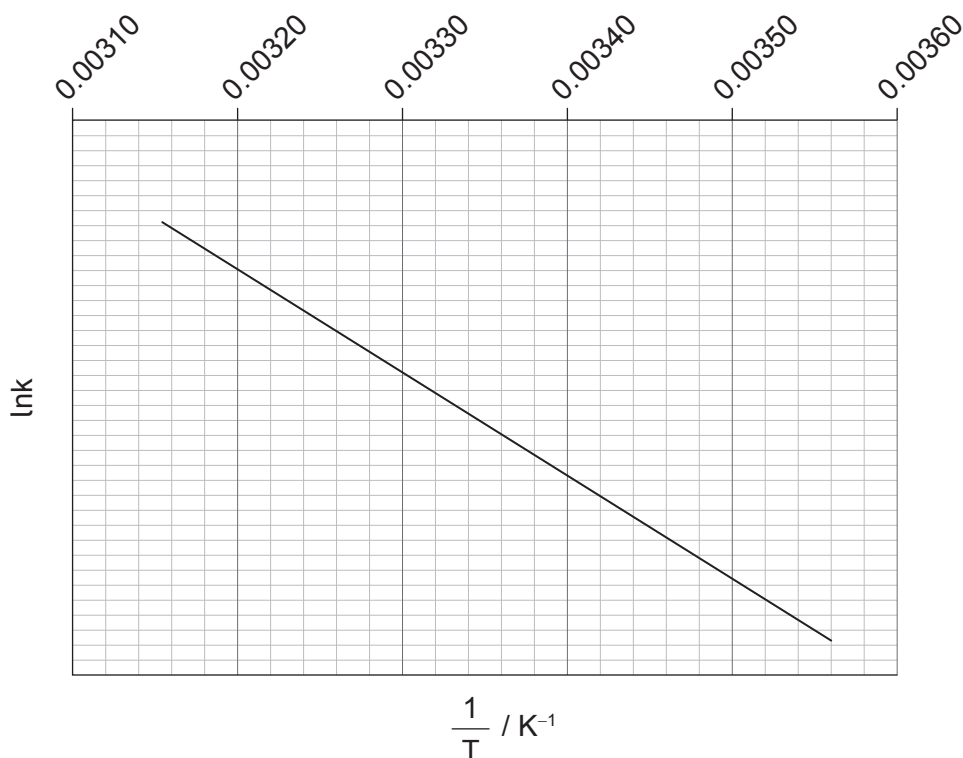
30. The following results were obtained from the acid-catalysed reaction between iodine, I_2 , and propanone, CH_3COCH_3 .

Experiment	Initial $[\text{CH}_3\text{COCH}_3]$ (mol dm^{-3})	Initial $[\text{I}_2]$ (mol dm^{-3})	Initial $[\text{H}^+]$ (mol dm^{-3})	Relative initial rate $\text{mol dm}^{-3} \text{s}^{-1}$
1	0.56	0.56	0.56	5.6×10^{-3}
2	0.28	0.56	0.28	1.4×10^{-3}
3	0.56	0.28	0.56	5.6×10^{-3}
4	0.56	0.56	0.28	2.8×10^{-3}

Which row gives the correct order of reaction for each reactant?

	CH_3COCH_3	I_2	H^+
A.	1	0	1
B.	1	1	0
C.	0	0	2
D.	0	1	1

31. The acid-catalysed reaction between iodine, I_2 , and propanone, CH_3COCH_3 , was carried out at various temperatures to find the activation energy. The following graph was obtained from the processed data, and the slope was calculated to be -6400 .



Which expression gives the activation energy for this reaction?

$$\ln k = \frac{-E_a}{RT} + \ln A$$

- A. $\frac{-6400 \times 1000}{R} \text{ kJ mol}^{-1}$
- B. $\frac{6400 \times R}{1000} \text{ kJ mol}^{-1}$
- C. $\frac{-6400 \times R}{1000} \text{ kJ mol}^{-1}$
- D. $\frac{6400 \times 1000}{R} \text{ kJ mol}^{-1}$

32. Which two species can be both Brønsted-Lowry acids and Brønsted-Lowry bases?
- A. H_3PO_4 and PO_4^{3-} .
- B. HPO_4^{2-} and H_2PO_4^- .
- C. HPO_4^{2-} and PO_4^{3-} .
- D. PO_4^{3-} and H_2PO_4^- .
33. A solution has a pH of 3.0. What is the hydroxide ion concentration, $[\text{OH}^-]$, in the solution?
- A. 11
- B. 10^{-3}
- C. 10
- D. 10^{-11}
34. Ammonia, NH_3 and nitrous acid, HNO_2 , are compounds of nitrogen. What are the oxidation states of nitrogen in these compounds?

	NH_3	HNO_2
A.	+3	+3
B.	–3	–3
C.	+3	–3
D.	–3	+3

35. Below is a reactivity series of selected elements, arranged from highest activity to lowest.

Zn
Fe
Cd
Co
Ni
Sn
Pb
Cu

Which reaction is spontaneous?

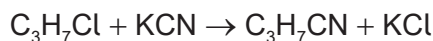
- A. $\text{Cd}^{2+}(\text{aq}) + \text{Pb}(\text{s}) \rightarrow \text{Pb}^{2+}(\text{aq}) + \text{Cd}(\text{s})$
 B. $\text{Fe}^{2+}(\text{aq}) + \text{Sn}(\text{s}) \rightarrow \text{Sn}^{2+}(\text{aq}) + \text{Fe}(\text{s})$
 C. $\text{Zn}^{2+}(\text{aq}) + \text{Cu}(\text{s}) \rightarrow \text{Cu}^{2+}(\text{aq}) + \text{Zn}(\text{s})$
 D. $\text{Ni}^{2+}(\text{aq}) + \text{Co}(\text{s}) \rightarrow \text{Co}^{2+}(\text{aq}) + \text{Ni}(\text{s})$
36. Which alcohol and conditions would produce the highest yield of methylpropanoic acid?

	Alcohol	Conditions
A.	2-methylpropan-2-ol	Reflux
B.	2-methylpropan-1-ol	Reflux
C.	2-methylpropan-2-ol	Distillation
D.	2-methylpropan-1-ol	Distillation

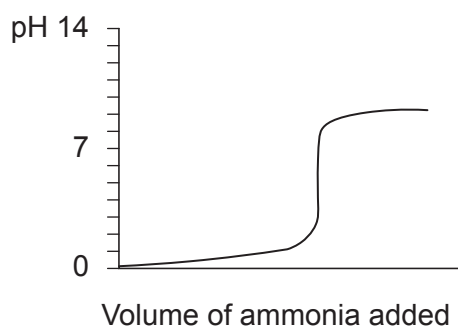
37. Which correctly shows heterolytic bond fission?

- A. $\text{Br} \text{---} \text{Br} \rightarrow \text{Br}^+ + \text{Br}^-$
 B. $\text{Br} \text{---} \text{Br} \rightarrow 2\text{Br}^\cdot$
 C. $\text{Br} \text{---} \text{Br} \rightarrow \text{Br}^+ + \text{Br}^-$
 D. $\text{Br} \text{---} \text{Br} \rightarrow 2\text{Br}^\cdot$

38. What is the role of the CN^- ion in the reaction of 1-chloropropane with excess KCN in ethanol?



- A. Electrophile and Lewis base
 B. Nucleophile and Lewis acid
 C. Electrophile and Lewis acid
 D. Nucleophile and Lewis base
39. When an excess of ammonia was added to hydrochloric acid, the following neutralization curve was obtained.



Which would be the best indicator for this titration?

	Indicator	$\text{p}K_a$
A.	Phenol red	7.9
B.	Bromothymol blue	7.0
C.	Phenolphthalein	9.6
D.	Bromocresol green	4.7

40. Which species would take part in a substitution reaction with benzene?

- A. Cl_2
 B. $\text{Cl}^\bullet$
 C. Cl^+
 D. Cl^-

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References:

10. 영원파란, 2017. N2O 루이스 구조 그리기. [online] Available at: <http://ywpop.tistory.com/7363> [Accessed 7 May 2024]. Source adapted.

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