Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Higher level
Paper 1A

16 May 2025

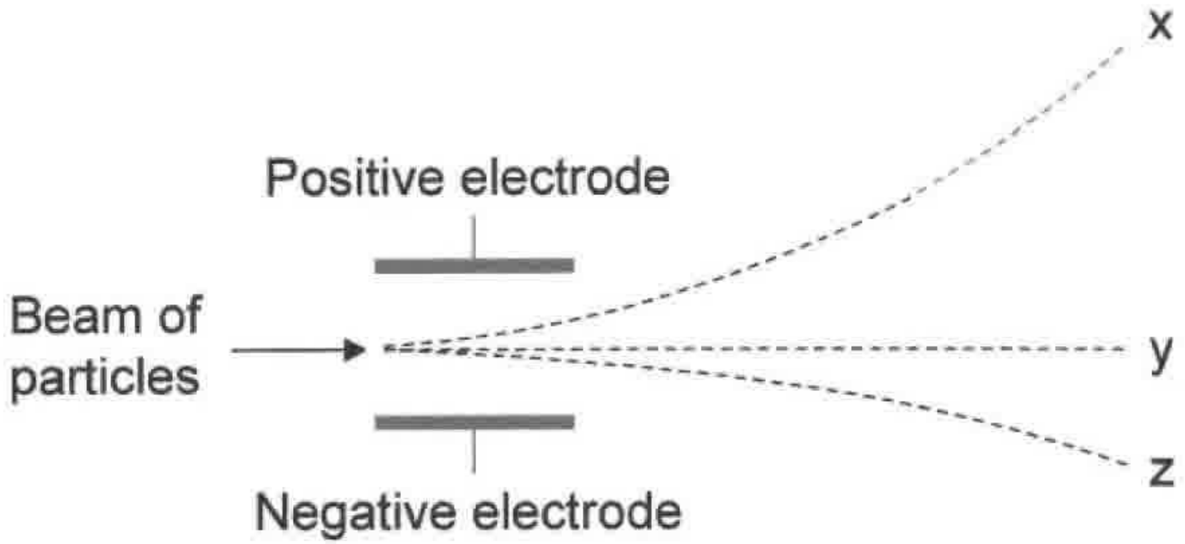
Zone A afternoon | **Zone B** afternoon | **Zone C** afternoon

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.

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

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.

$^{24}_{12}W^{2+}$ $^{31}_{16}X^{-}$ $^{45}_{21}Y^{2+}$ $^{19}_{9}Z^{-}$

A. X and Y

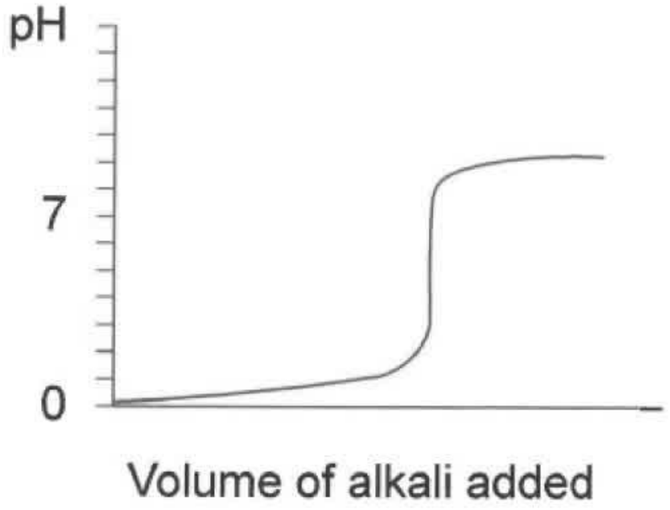
B. X and W

C. Z and Y

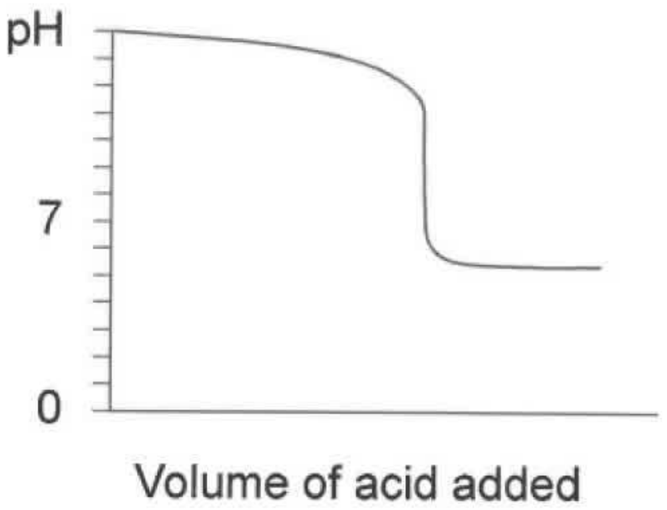
D. Z and W

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

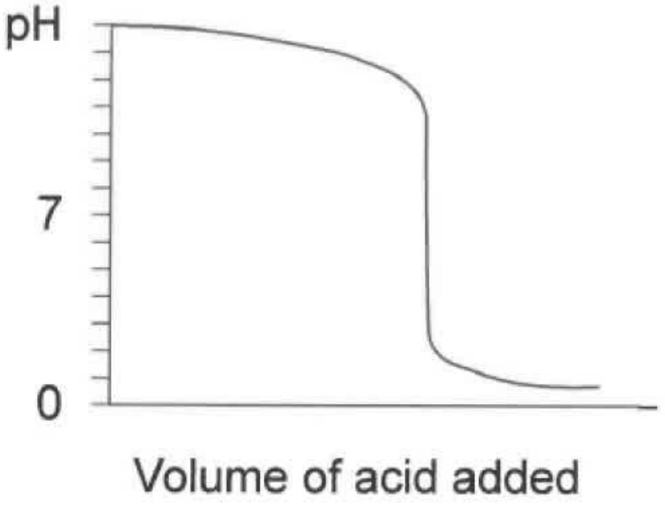
A.



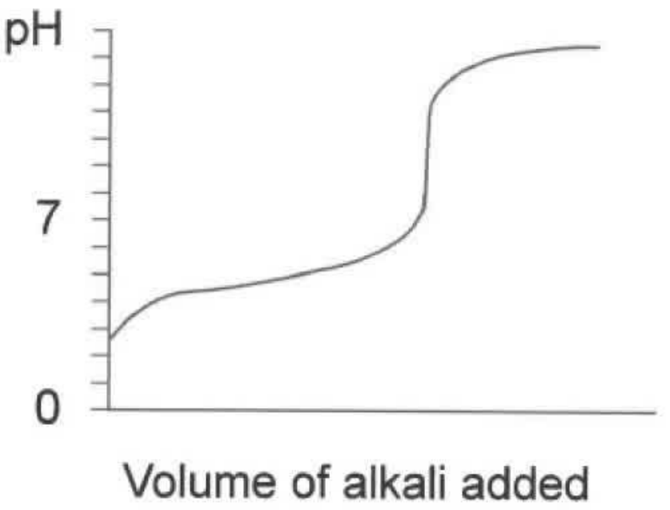
B.



C.



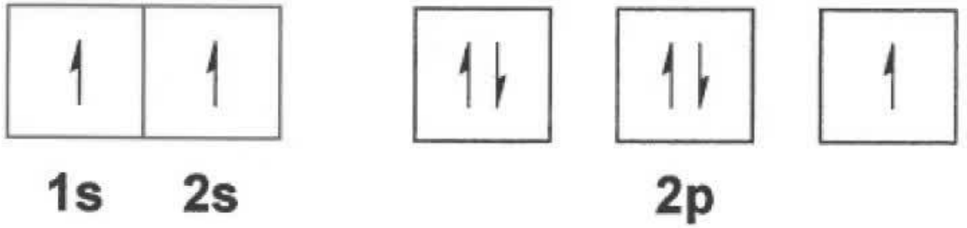
D.



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

A. 

B. 

C. 

D. 

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?

A.

s p

B.

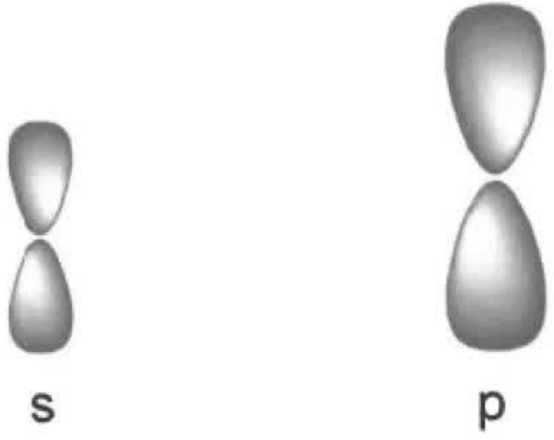
s p

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

A.

B.

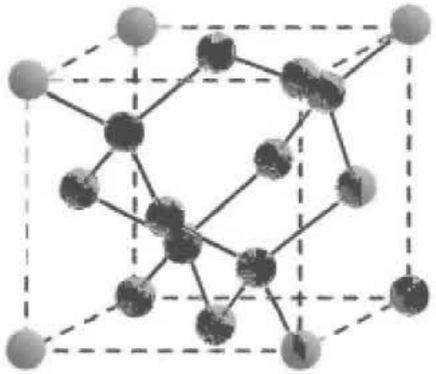
C.



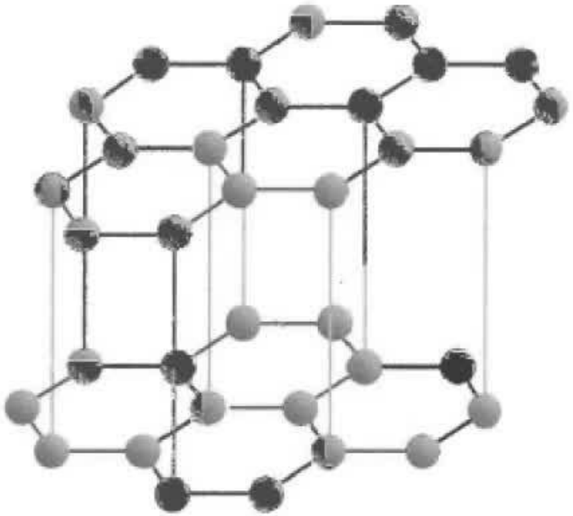
D.

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

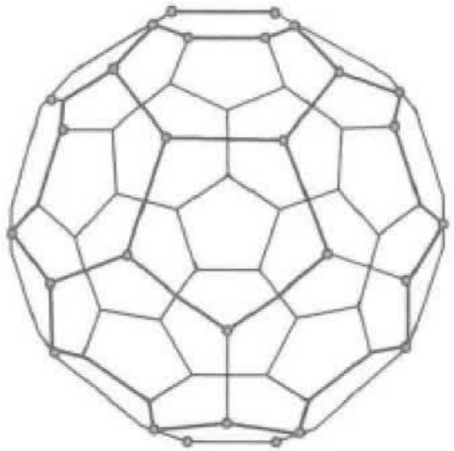
W



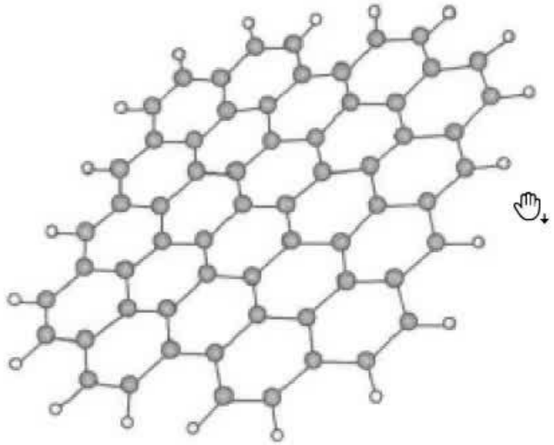
X



Y

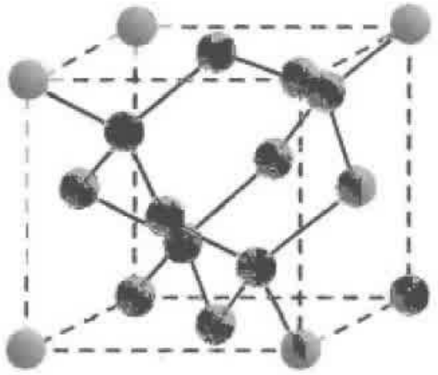


Z

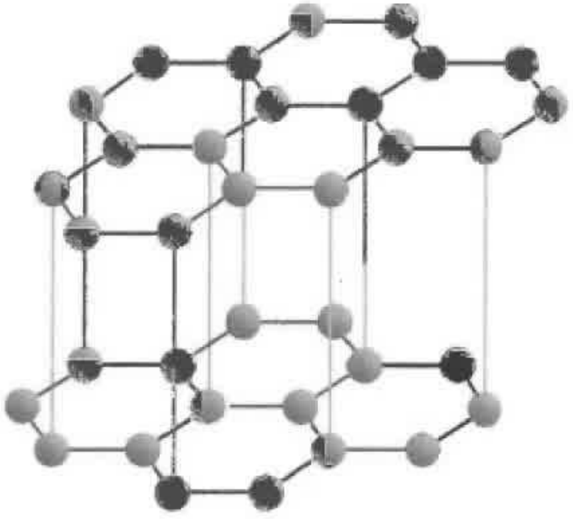


	Graphene	Fullerene	Graphite	Diamond
A.	Z	Y	X	W

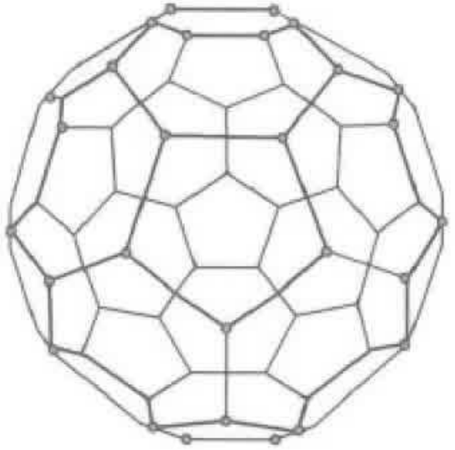
W



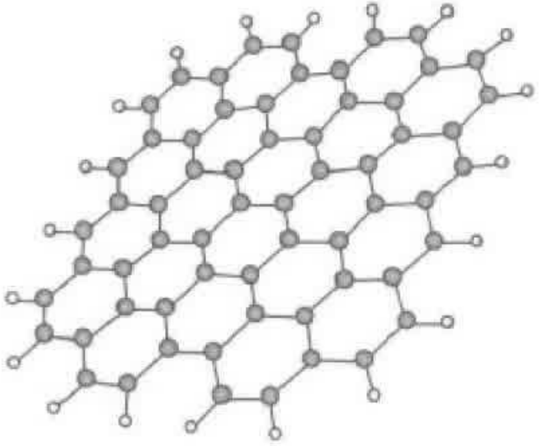
X



Y



Z



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

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

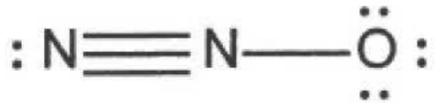
A. I and II only

B. I and III only

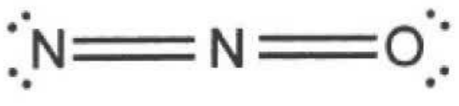
C. II and III only

D. I, II and III

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

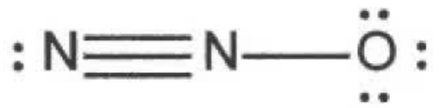
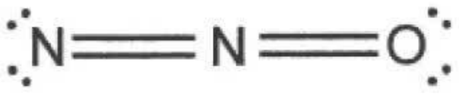


Structure X



Structure Y

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

	Structure X 			Structure Y 			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

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?

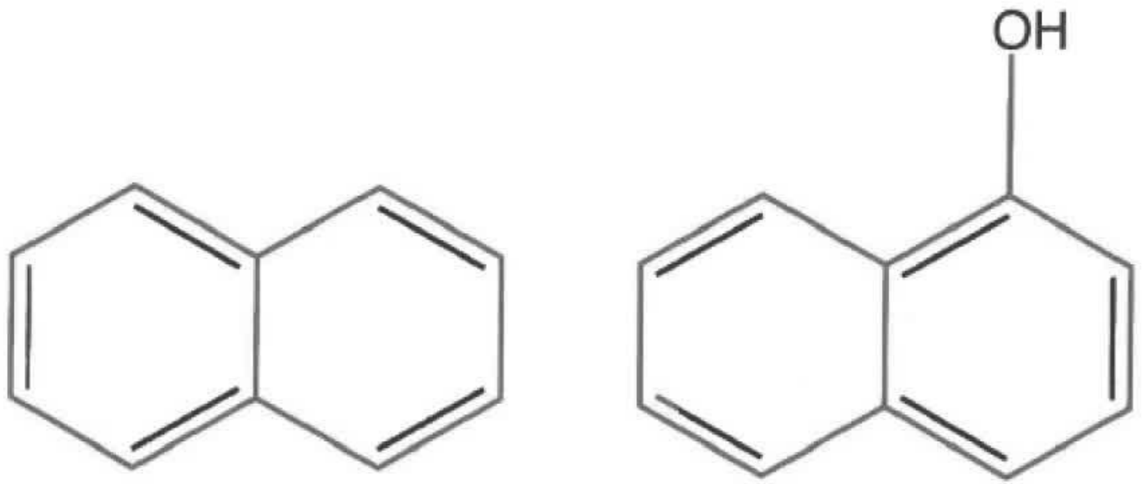
A. NH_3, H_2O, C_2H_4, CH_4

B. H_2O, C_2H_4, CH_4, NH_3

C. C_2H_4, CH_4, NH_3, H_2O

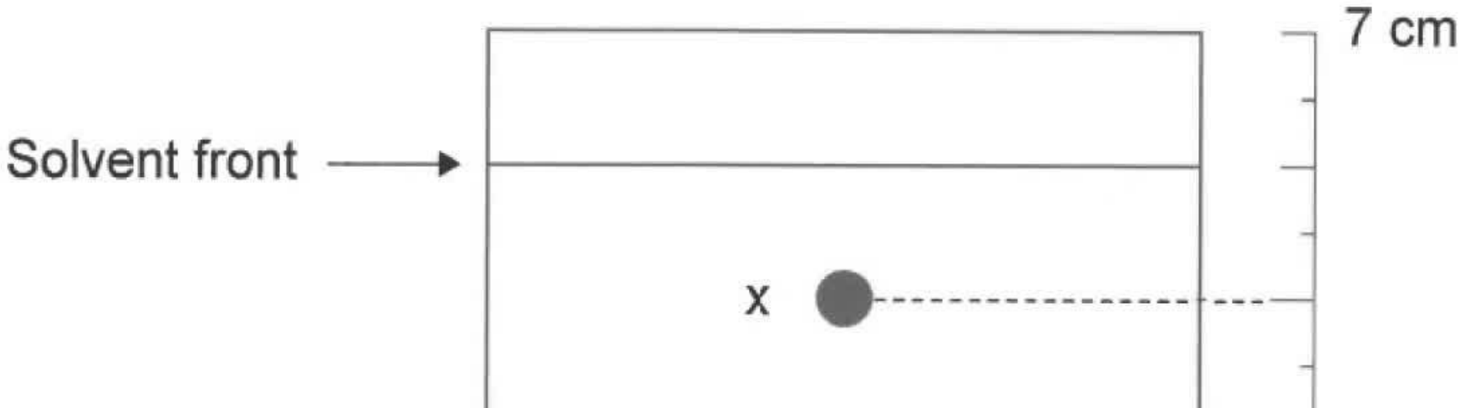
D. CH_4, NH_3, H_2O, C_2H_4

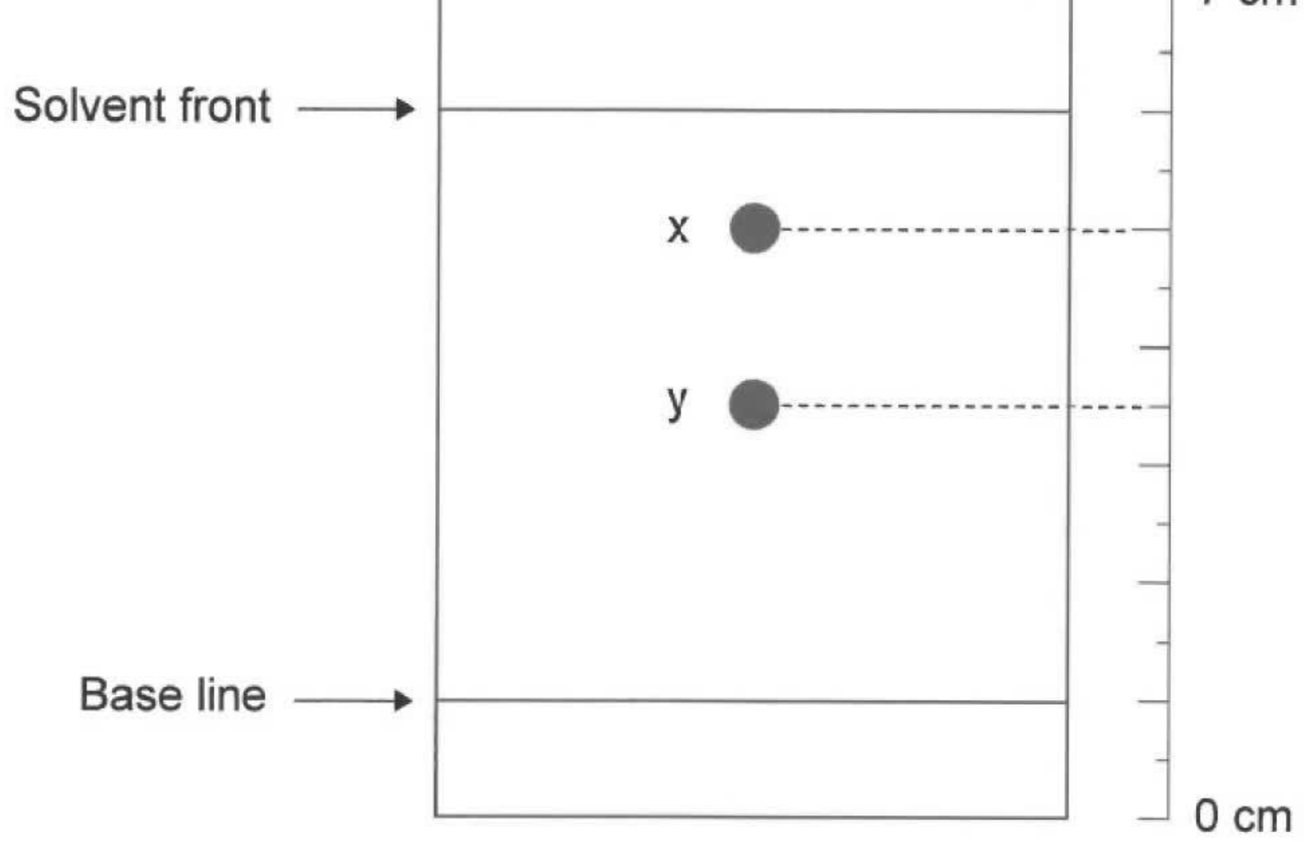
12. The following thin-layer chromatogram was obtained from a mixture of naphthalene, $C_{10}H_8$, and naphthol, $C_{10}H_8O$. A polar silica was used as the stationary phase, and a non-polar hexane as the mobile phase.



Naphthalene

Naphthol





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?

A. Benzene has the formula C_6H_6.

B. Benzene is an unsaturated molecule.

C. All C–C bonds have the same length.

D. Benzene can be hydrogenated.

14. Germanium has several stable oxidation states. Which row shows these species in order of increasing radius?

A. Ge^{4+}, Ge^{2+}, Ge, Ge^{4-}.

B. Ge^{4-}, Ge^{4+}, Ge^{2+}, Ge.

C. Ge, Ge^{4-}, Ge^{4+}, Ge^{2+}.

D. Ge^{2+}, Ge, Ge^{4-}, Ge^{4+}.

15. Which statement explains the trend in first ionisation energy from sodium, Na, to chlorine,Cl?

15. Which statement explains the trend in first ionisation energy from sodium, Na, to chlorine,Cl?

A. Nuclear charge increases.

B. Electronegativity decreases.

C. Atomic radius increases.

D. Shielding decreases.

16. Which elements would react with each other most vigorously?

A. K(s) and $Br_2(g)$.

B. K(s) and $Cl_2(g)$.

C. Na(s) and $Br_2(g)$.

D. 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?

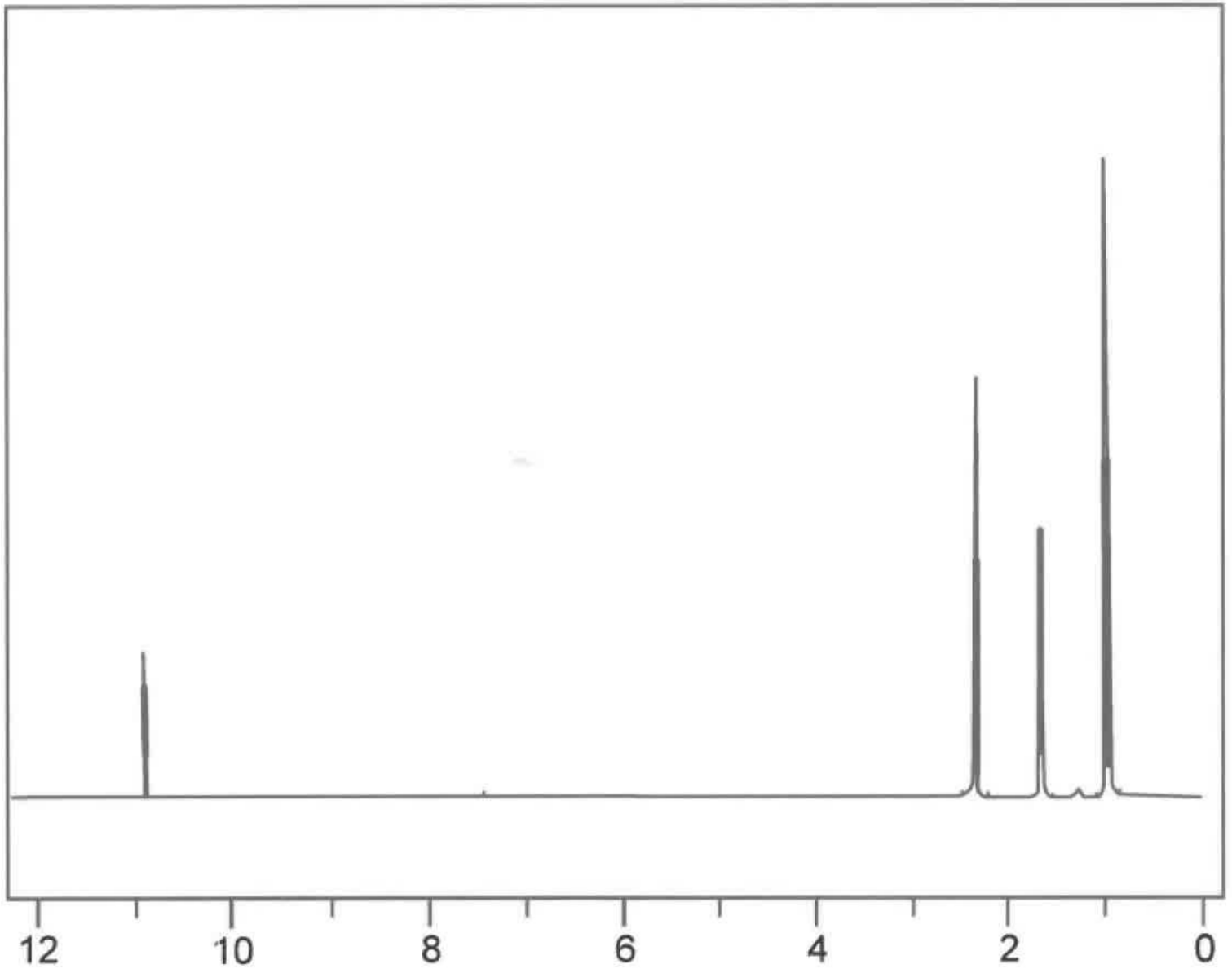
A. d-Electrons are delocalized.

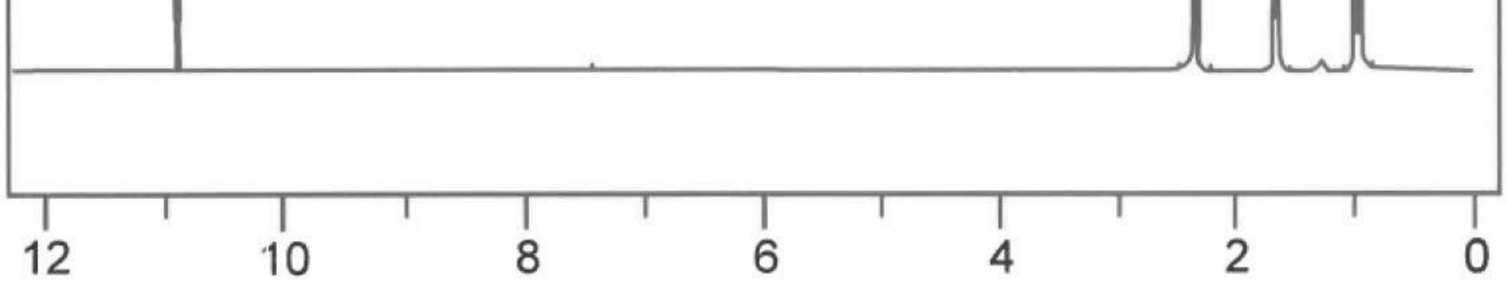
B. All have a +2 oxidation state.

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 ^{1}H NMR spectrum?





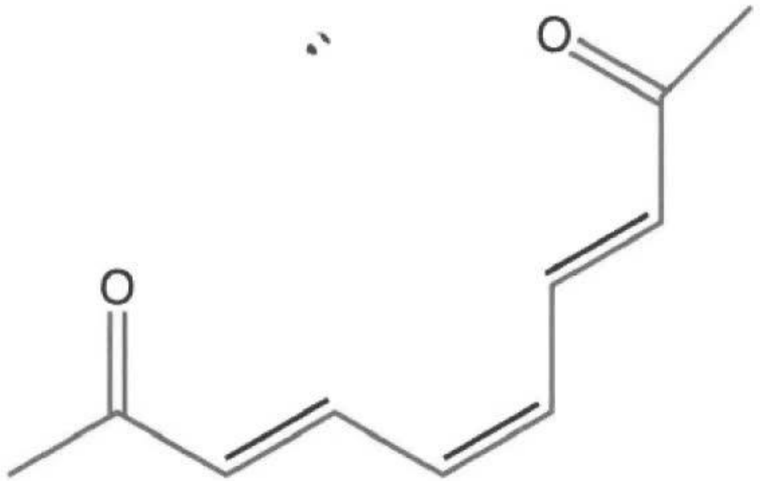
A. Butanoic acid

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?

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, $\Delta H^{\ominus}_{f}$, of a compound and enthalpy of combustion, $\Delta H^{\ominus}_{c}$, of its elements?

A. $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$

B. $\frac{1}{2}N_2(g) + 1\frac{1}{2}H_2(g) \rightarrow NH_3(g)$

C. $2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$

D. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$

23. 0.050 mol of sodium hydrogencarbonate was added to 50 cm^3 of 2.0 mol dm^{-3} solution of citric acid.

$$C_6H_8O_7(aq) + 3NaHCO_3(s) \rightarrow C_6H_5O_7Na_3(aq) + 3CO_2(g) + 3H_2O(l)$$

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}? ($c_w = 4.18\ J\ g^{-1}\ K^{-1}$, $Q = mc\Delta T$)

A. +4.18

B. –4.18

C. +12.5

D. –12.5

24. The table shows enthalpy of combustion data for several substances.

Substance	$\Delta H^{\ominus}_c$ (kJ mol^{-1})
C_2H_6	–1561
C_2H_4	–1411
H_2	–286

24. The table shows enthalpy of combustion data for several substances.

Substance	$\Delta H^{\ominus}_c$ (kJ mol^{-1})
C_2H_6	–1561
C_2H_4	–1411
H_2	–286

Which expression would give the enthalpy for the following reaction?

$$C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$$

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. $-1561 + 286 - 1411$

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. $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

B. $CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$

C. $I_2(g) + H_2(g) \rightarrow 2HI(g)$

D. $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

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

$$C_2H_6(g) + Cl_2(g) \rightarrow C_2H_5Cl(g) + HCl(g)$$

($C_2H_6 = 30.08\,g\,mol^{-1}$, $Cl_2 = 70.90\,g\,mol^{-1}$, $C_2H_5Cl = 64.52\,g\,mol^{-1}$, $HCl = 36.46\,g\,mol^{-1}$)

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

What is the atom economy for this reaction?

A. 15.7 %

B. 46.6 %

C. 63.9 %

D. 99.9 %

27. 75 cm^3 of propane was completely combusted in 400 cm^3 of oxygen according to the following equation.

C. 63.9 %

D. 99.9 %

27. 75 cm^3 of propane was completely combusted in 400 cm^3 of oxygen according to the following equation.

$$CH_3CH_2CH_3(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

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

A. 25 cm^3.

B. 50 cm^3.

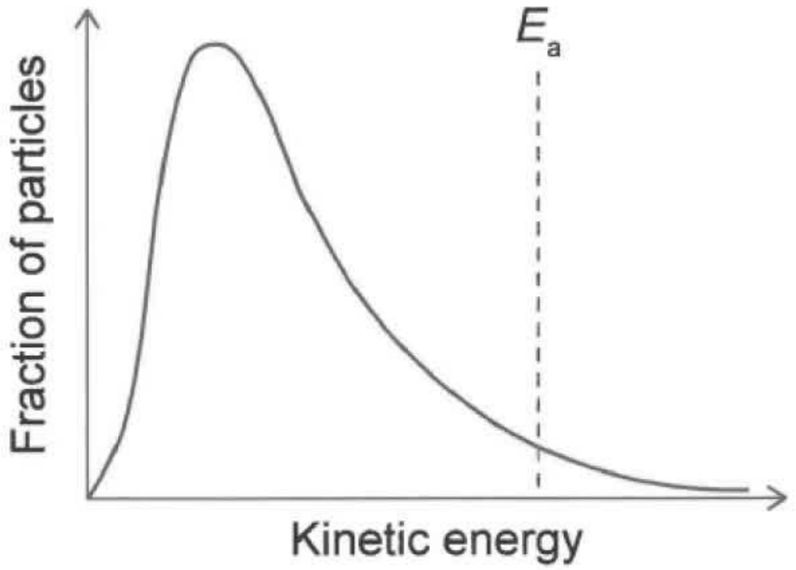
C. 75 cm^3.

D. 150 cm^3.

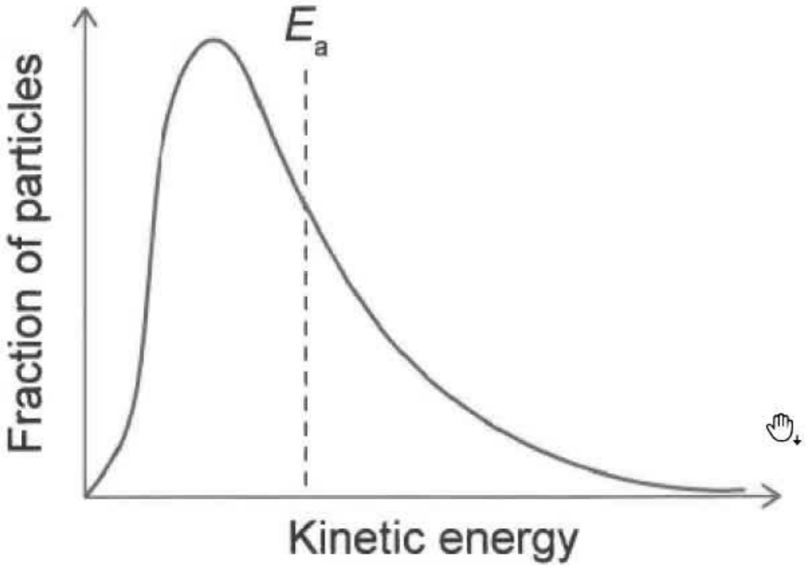
28. Consider the following Maxwell-Boltzmann distribution.

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

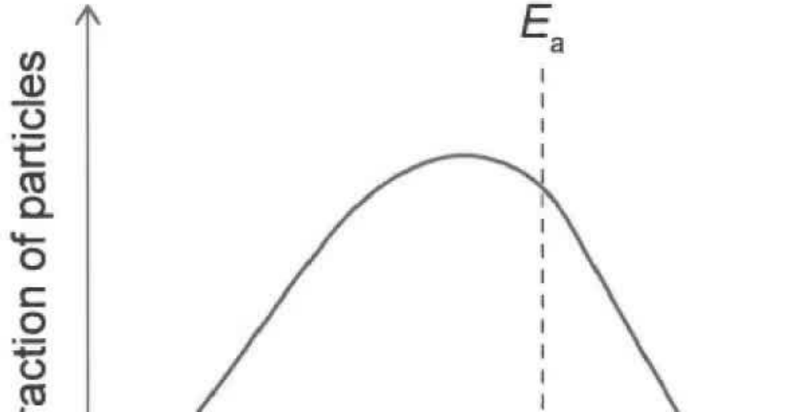
A.



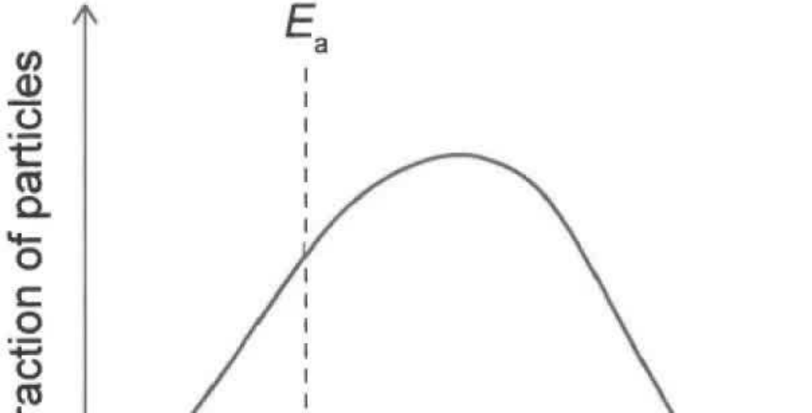
B.



C.

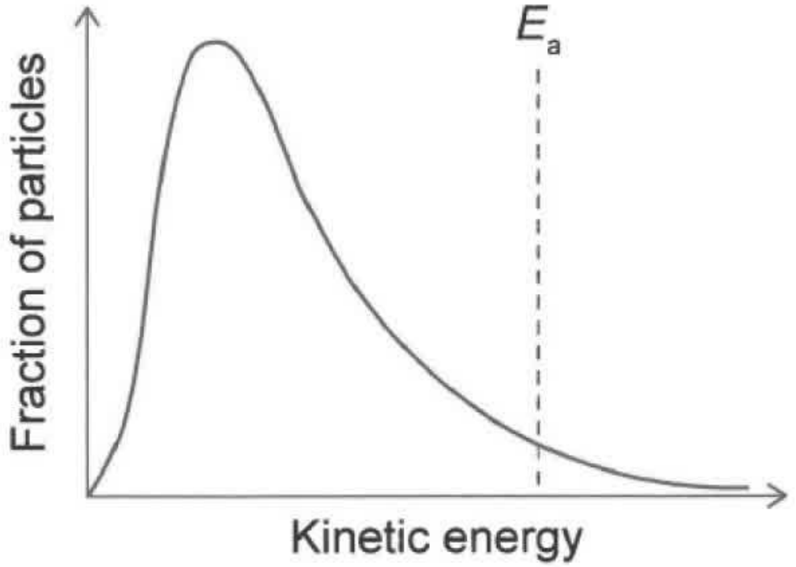


D.

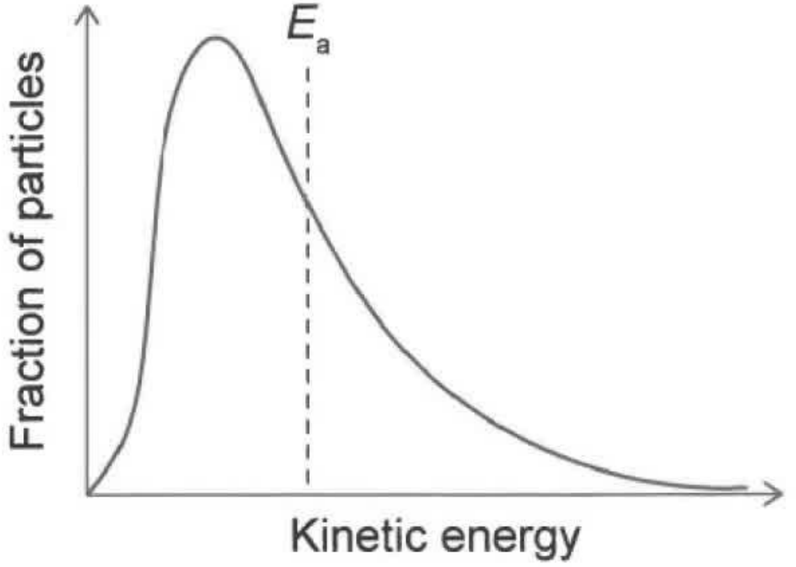


Which represents the distribution and value of activation energy at a lower temperature?

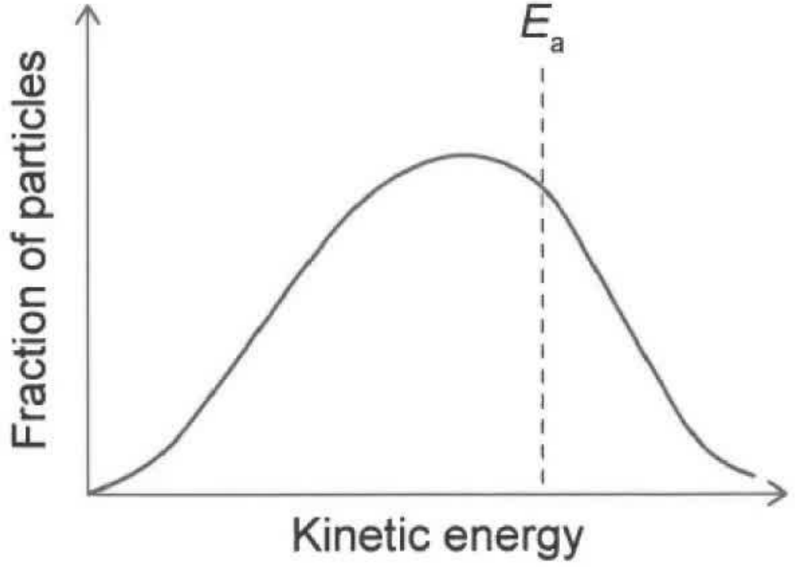
A.



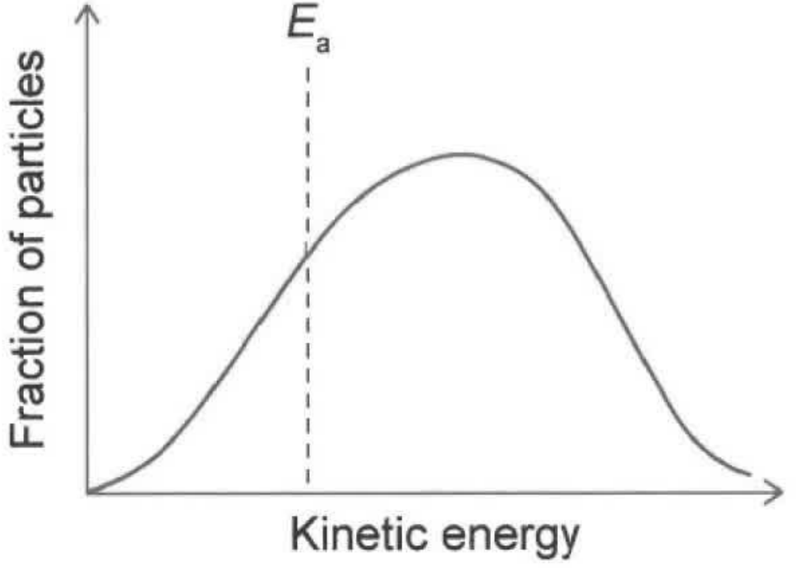
B.

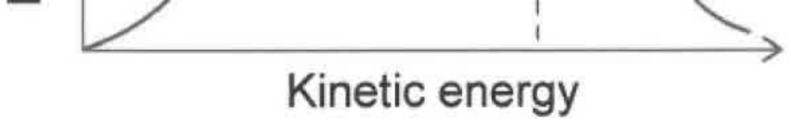


C.



D.





29. Consider the following system at equilibrium:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H_r^{\ominus} = -46\,kJ\,mol^{-1}$$

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	$Q < K$

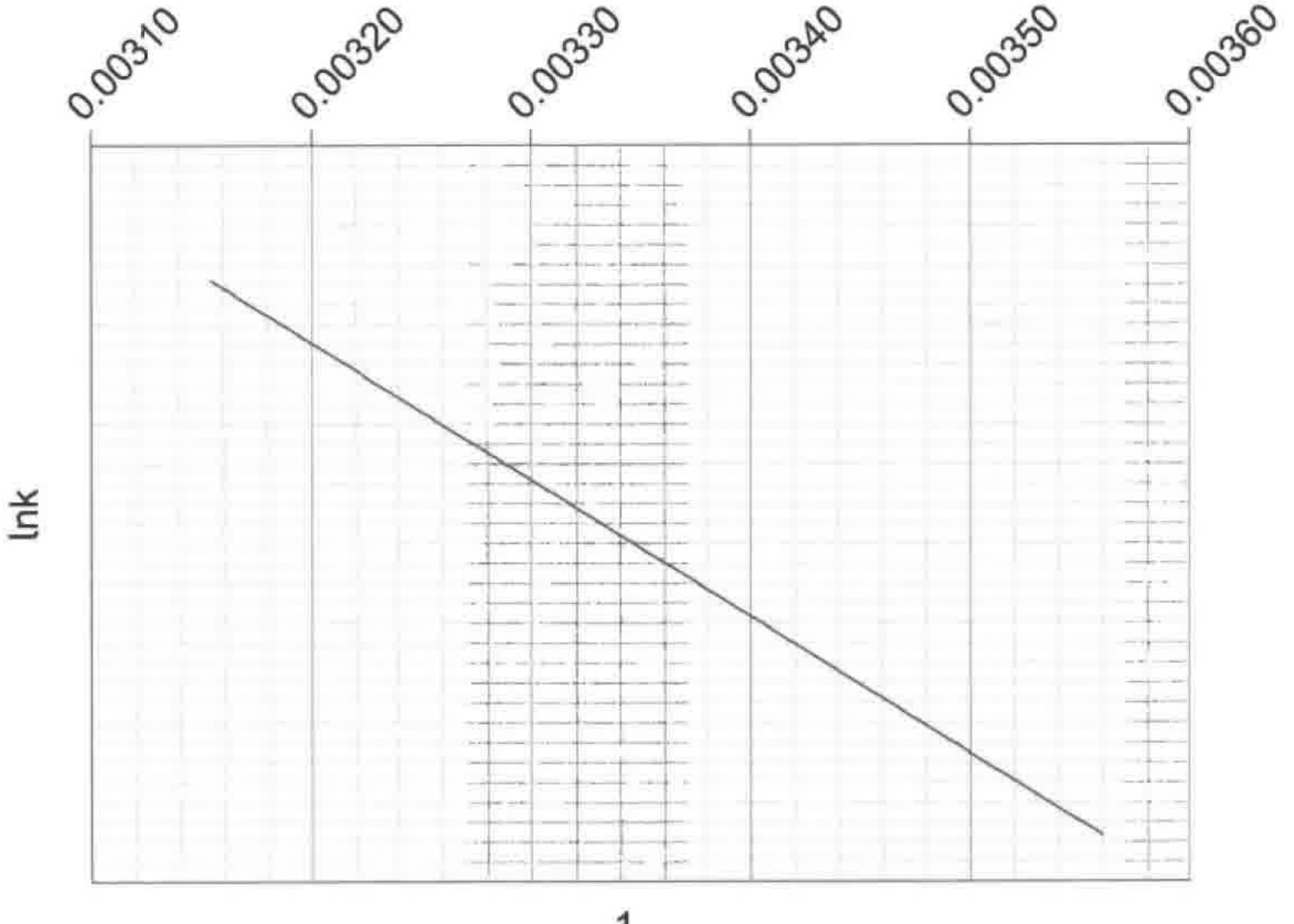
30. The following results were obtained from the acid-catalysed reaction between iodine, I_2, and propanone, CH_3COCH_3.

Experiment	Initial $[CH_3COCH_3]$ ($mol\,dm^{-3}$)	Initial $[I_2]$ ($mol\,dm^{-3}$)	Initial $[H^+]$ ($mol\,dm^{-3}$)	Relative initial rate $mol\,dm^{-3}\,s^{-1}$
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.



$\frac{1}{T}$ / K^{-1}

Which expression gives the activation energy for this reaction?

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

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

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

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

D. $\frac{6400 \times 1000}{R}$ 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, $[OH^-]$, 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?

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. $Cd^{2+}(aq) + Pb(s) \rightarrow Pb^{2+}(aq) + Cd(s)$

B. $Fe^{2+}(aq) + Sn(s) \rightarrow Sn^{2+}(aq) + Fe(s)$

C. $Zn^{2+}(aq) + Cu(s) \rightarrow Cu^{2+}(aq) + Zn(s)$

D. $Ni^{2+}(aq) + Co(s) \rightarrow Co^{2+}(aq) + Ni(s)$

36. Which alcohol and conditions would produce the highest yield of methylpropanoic acid?

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. 

B. 

C. 

D. 

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

$$C_3H_7Cl + KCN \rightarrow C_3H_7CN + KCl$$

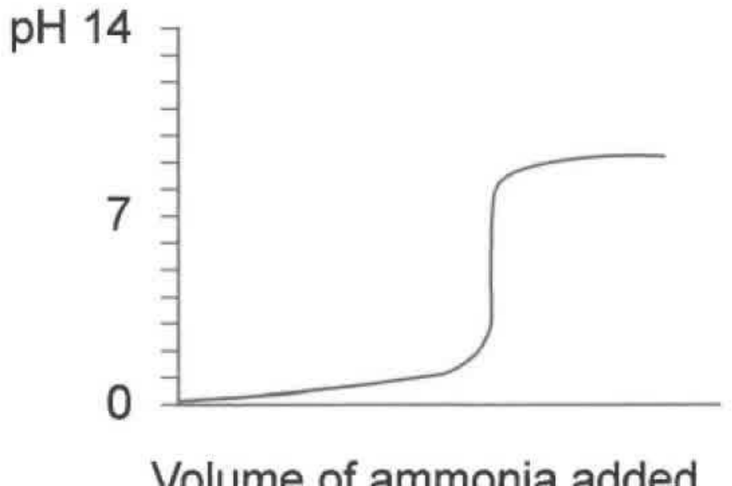
A. Electrophile and Lewis base

B. Nucleophile and Lewis acid

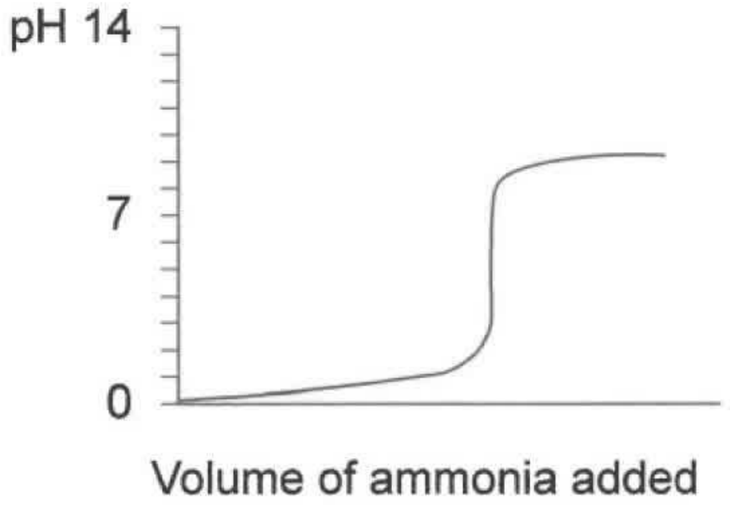
C. Electrophile and Lewis acid

D. Nucleophile and Lewis base

39. When an excess of ammonia was added to hydrochloric acid, the following neutralization curve was obtained.



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	pk_a
A.	Phenol red	7.9
B.	Bromothymol blue	7.0
C.	Phenolphthalein	9.6
D.	Bromocresol green	4.7

	Indicator	pk_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. $Cl\bullet$

C. Cl^+

D. Cl^-