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CHEMISTRY
HIGHER LEVEL
PAPER 1

Monday 19 May 2014 (afternoon)

1 hour

INSTRUCTIONS TO CANDIDATES

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The periodic table is provided for reference on page 2 of this examination paper.
- The maximum mark for this examination paper is *[40 marks]*.

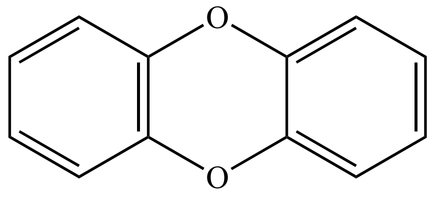
The Periodic Table

Atomic number
Element
Relative atomic mass

1	2											3	4	5	6	7	0
1 **H** 1.01																	2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.90	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.71	29 **Cu** 63.55	30 **Zn** 65.37	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** 98.91	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.40	49 **In** 114.82	50 **Sn** 118.69	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.30
55 **Cs** 132.91	56 **Ba** 137.34	57 † **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.85	75 **Re** 186.21	76 **Os** 190.21	77 **Ir** 192.22	78 **Pt** 195.09	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.37	82 **Pb** 207.19	83 **Bi** 208.98	84 **Po** (210)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 ‡ **Ac** (227)															

†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** 146.92	62 **Sm** 150.35	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.92	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (242)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (254)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

1. The structural formula of a dioxin is shown below.



What is its empirical formula?

A. C_6O

B. C_6H_4O

C. C_6H_6O

D. $C_{12}H_8O_2$

2. Under which conditions does CH_4 have the same number of molecules as $100\,cm^3$ of O_2 at $27\,°C$ and 1.0×10^5 Pa?

	Volume / cm^3	Temperature / °C	Pressure / 10^5 Pa
A.	50	54	1.0
B.	50	327	1.0
C.	100	54	2.0
D.	100	327	2.0

3. $100.0\,cm^3$ of a $0.50\,mol\,dm^{-3}$ solution of $BaCl_2$ is added to $50.0\,cm^3$ of a $0.10\,mol\,dm^{-3}$ solution of Na_2SO_4. A precipitate of $BaSO_4$ is formed according to the equation below.

$$BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$$

What is the amount, in mol, of $BaSO_4$ produced?

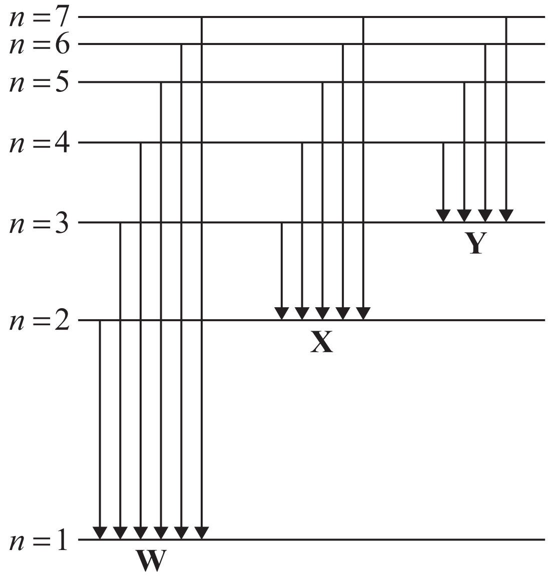
A. 0.0050

B. 0.010

C. 0.050

D. 0.10

4. The diagram represents the emission spectrum of hydrogen. Groups of arrows are labelled **W**, **X** and **Y**.



Which statement is correct?

A. The arrows represent the transition of electrons to different energy levels when heat is supplied.

B. The arrows of **W** represent emission in the UV region.

C. The smallest arrow of **X** represents a violet line in the emission spectrum.

D. The arrows of **Y** represent emission of electromagnetic waves with higher energy than those represented by **X** and **W**.

5. Which electron configurations do **not** follow the Hund's rule?

	1s	2s	2p		
I.	↑ ↓	↑ ↓	↑	↑	↑
II.	↑ ↓	↑ ↓	↑ ↓	↑	
III.	↑ ↓	↑ ↓	↑	↓	↑

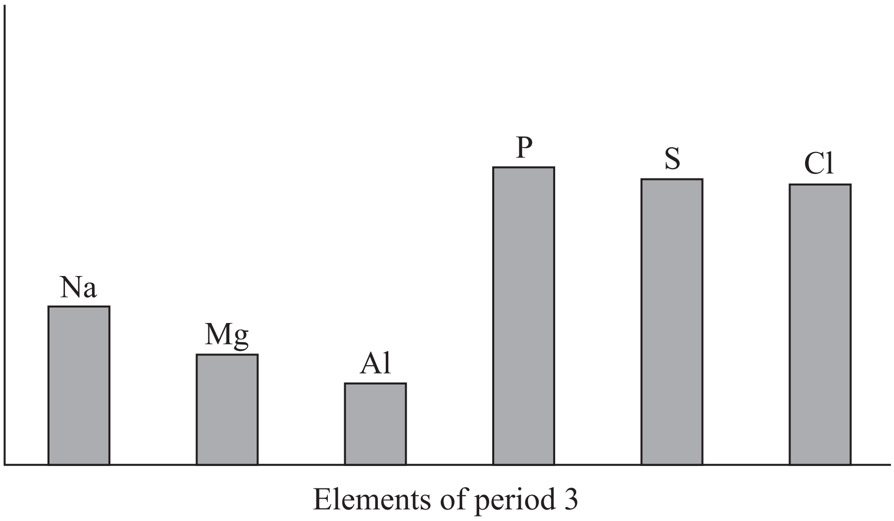
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

6. The horizontal axis of the bar chart represents the elements of period 3 from sodium to chlorine (excluding silicon). What could the vertical axis represent?



A. Melting point of the element

B. Electronegativity of the bonded atom

C. Ionic radius of the most common ion

D. First ionization energy in the gaseous state

7. Which statements about reactivity are correct?

I. Potassium reacts more vigorously than sodium with chlorine.

II. Lithium reacts more vigorously than potassium with water.

III. Fluorine reacts more vigorously than bromine with a potassium iodide solution.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

8. Which ion is colourless?

A. $[Sc(H_2O)_6]^{3+}$

B. $[Cr(H_2O)_6]^{3+}$

C. $[Fe(H_2O)_6]^{3+}$

D. $[Fe(CN)_6]^{3-}$

9. The electronegativities of four elements are given in the table.

Element	W	X	Y	Z
Electronegativity	0.9	1.1	3.4	4.0

Which statement is correct?

A. W and X form an ionic compound.

B. W and X form a covalent compound.

C. Y and Z form an ionic compound.

D. Y and Z form a covalent compound.

10. Which combination of length and strength of the carbon–to–carbon bonds in C_2H_2 and C_2H_4 is correct?

	Bond length	**Bond strength**
A.	$C_2H_2 > C_2H_4$	$C_2H_2 < C_2H_4$
B.	$C_2H_2 > C_2H_4$	$C_2H_2 > C_2H_4$
C.	$C_2H_2 < C_2H_4$	$C_2H_2 < C_2H_4$
D.	$C_2H_2 < C_2H_4$	$C_2H_2 > C_2H_4$

11. A solid has a melting point of 1582 °C and does not dissolve in water. It does not conduct electricity in the molten state. What type of structure does the solid have?

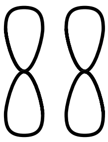
A. Ionic

B. Metallic

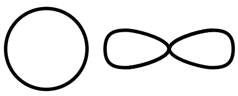
C. Giant molecular

D. Simple molecular

12. The diagrams below show *s* and *p* orbitals in different positions. Which combinations can form a σ-bond?

I. 

II. 

III. 

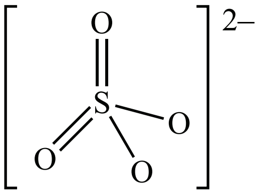
A. I and II only

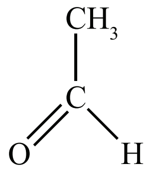
B. I and III only

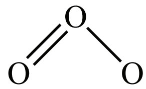
C. II and III only

D. I, II and III

13. Which species contain delocalized electrons?

I. 

II. 

III. 

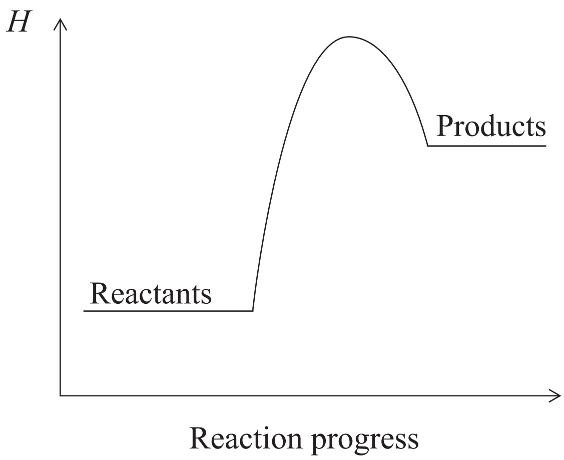
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

14. Which statement is correct for the reaction with this enthalpy level diagram?



A. Heat energy is released during the reaction and the reactants are more stable than the products.

B. Heat energy is absorbed during the reaction and the reactants are more stable than the products.

C. Heat energy is released during the reaction and the products are more stable than the reactants.

D. Heat energy is absorbed during the reaction and the products are more stable than the reactants.

15. The enthalpy changes of three reactions are given below.

$$2HCOOH(l) + O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l) \qquad \Delta H = a$$

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l) \qquad \Delta H = b$$

$$2HCOOC_2H_5(l) + 7O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l) \qquad \Delta H = c$$

What is the enthalpy change for the following reaction?

$$HCOOH(l) + C_2H_5OH(l) \rightarrow HCOOC_2H_5(l) + H_2O(l)$$

A. $a + b + c$

B. $a + 2b - c$

C. $\frac{1}{2}a + b + \frac{1}{2}c$

D. $\frac{1}{2}a + b - \frac{1}{2}c$

16. What is the correct definition of lattice enthalpy?

A. Enthalpy change when one mole of a solid ionic compound is separated into gaseous ions.

B. Enthalpy change when one mole of a solid ionic compound is separated into its ions in their standard state.

C. Enthalpy change when one mole of a solid ionic compound is formed from gaseous elements.

D. Enthalpy change when one mole of a compound is formed from the elements in their standard states.

17. Which reaction has the greatest increase in entropy?

A. $2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l)$

B. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

C. $2HCl(aq) + MgCO_3(s) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$

D. $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

18. Which change **must** be negative when a reaction occurs spontaneously?

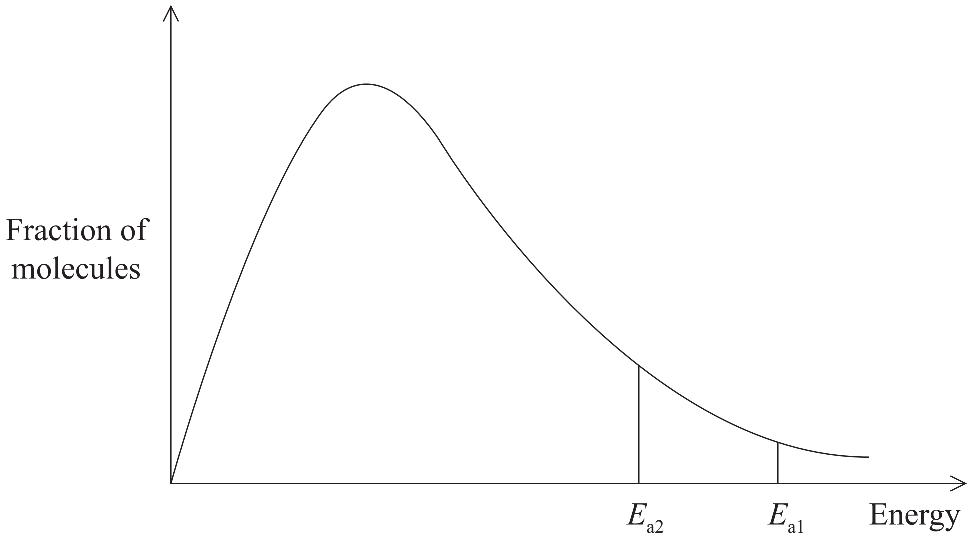
A. ΔH

B. ΔG

C. ΔS

D. ΔT

19. The diagram represents the Maxwell–Boltzmann energy distribution curve of the reactants for a chemical reaction with different activation energies, E_{a1} and E_{a2}.



What is the reason why the rate of the reaction with activation energy E_{a2} is greater?

A. More frequent collisions between the particles occur.

B. More energetic collisions between the particles occur.

C. A catalyst has been added.

D. The temperature is higher.

20. X and Y react according to the equation $2X + Y \rightarrow Z$. The reaction can be described by the following mechanism:

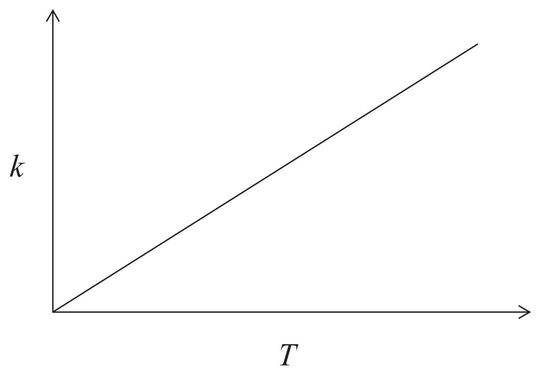
$$X + X \rightarrow X_2 \qquad \textit{slow}$$
$$X_2 + Y \rightarrow Z \qquad \textit{fast}$$

What is the order of the reaction with respect to **X** and **Y**?

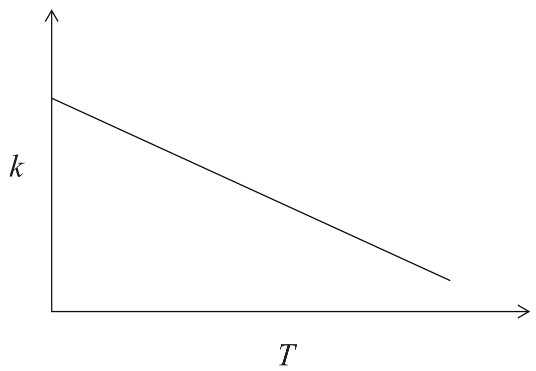
	X	**Y**
A.	First	Zero
B.	First	First
C.	Second	Zero
D.	Second	First

21. The rate constant for a reaction is determined at different temperatures. Which diagram represents the relationship between the rate constant, k, and temperature, T, in K?

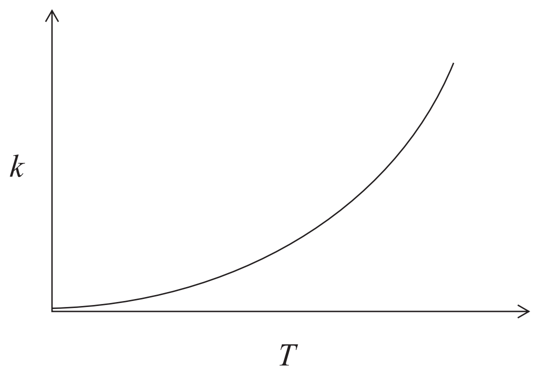
A.



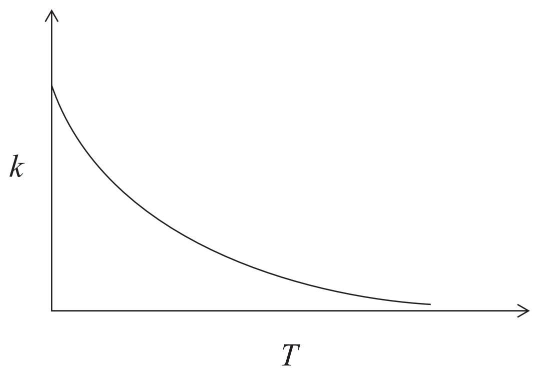
B.



C.



D.



22. Which statement is correct for a reversible reaction when $K_c >> 1$?

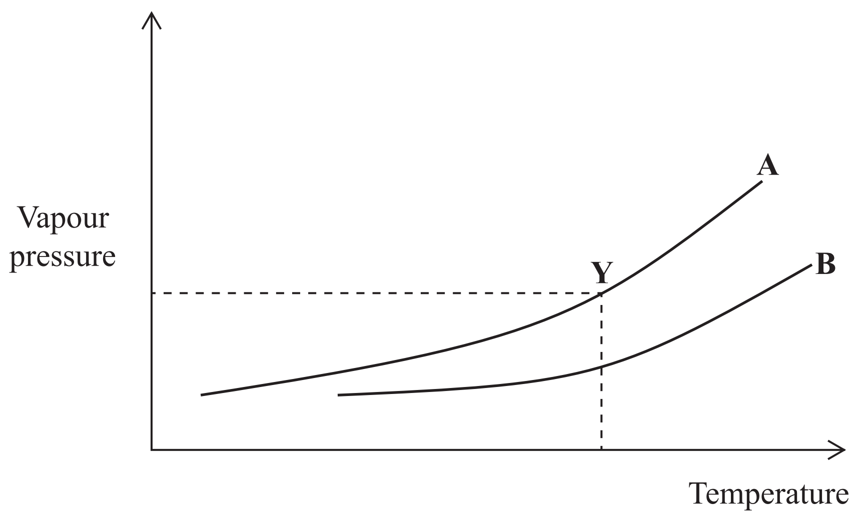
A. The reaction almost goes to completion.

B. The reaction hardly occurs.

C. Equilibrium is reached in a very short time.

D. At equilibrium, the rate of the forward reaction is much higher than the rate of the backward reaction.

23. The diagram represents the vapour pressure of two liquids, **A** and **B**, as temperature changes. **Y** is a point on the curve of liquid **A**.



Which statement can be made using the graph?

A. At the conditions of pressure and temperature at point **Y**, **A** is in the liquid phase and **B** in the gaseous phase.

B. At the conditions of pressure and temperature at point **Y**, both **A** and **B** are in the gaseous phase.

C. At the same pressure, **A** has a higher boiling point than **B**.

D. The intermolecular forces between the molecules of **B** are stronger than between the molecules of **A**.

24. In which reaction does H_2O act as a Lewis base but **not** as a Brønsted–Lowry base.

A. $H_2O + NH_4^+ \rightarrow H_3O^+ + NH_3$

B. $H_2O + CaO \rightarrow Ca^{2+} + 2OH^-$

C. $H_2O + [Fe(H_2O)_6]^{3+} \rightarrow Fe[(OH)(H_2O)_5]^{2+} + H_3O^+$

D. $6H_2O + [Ni(NH_3)_6]^{2+} \rightarrow 6NH_3 + [Ni(H_2O)_6]^{2+}$

25. A solution of 50 cm^3 hydrochloric acid has a pH of 4. What is the final pH if 450 cm^3 of water is added?

A. 3

B. 4

C. 5

D. 6

26. The pK_b of HS^- is 7.08. What is its conjugate acid and what is the K_a value of the acid?

	Conjugate acid	K_a
A.	H_2S	$10^{-6.92}$
B.	H_2S	6.92
C.	S^{2-}	$10^{-6.92}$
D.	S^{2-}	6.92

27. Which mixture of solutions can be used to prepare a buffer solution?

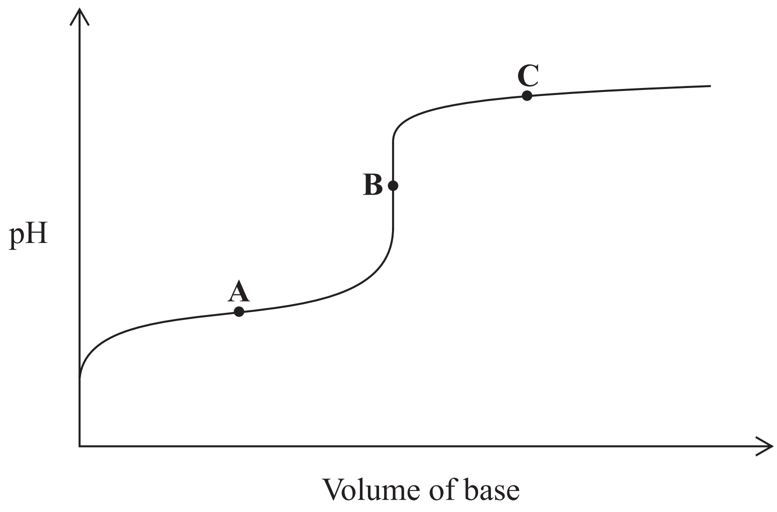
A. 50.0 cm^3 0.100 mol dm^{-3} HCl and 100.0 cm^3 0.100 mol dm^{-3} NH_3

B. 50.0 cm^3 0.100 mol dm^{-3} HCl and 50.0 cm^3 0.100 mol dm^{-3} NH_3

C. 50.0 cm^3 0.100 mol dm^{-3} HCl and 100.0 cm^3 0.100 mol dm^{-3} NH_4Cl

D. 50.0 cm^3 0.100 mol dm^{-3} HCl and 50.0 cm^3 0.100 mol dm^{-3} NH_4Cl

28. A weak acid is titrated with a strong base. Which statement is true for the titration curve?



A. **A** is the equivalence point.

B. The pH at **A** equals the pK_a of the acid.

C. The pH at **B** equals 7.

D. **C** is in the buffer region.

29. Methyl orange is an indicator which changes its colour from red to yellow in a pH range of 3.2 – 4.4. For which titration would methyl orange be a suitable indicator?

A. Iodine and sodium thiosulfate solution

B. Hydrochloric acid and ammonia solution

C. Ethanoic acid and sodium hydroxide solution

D. Ethanoic acid and ammonia solution

30. At which side of the equation are electrons, H^+ ions and H_2O needed to complete the half-equation?

$$MnO_4^-(aq) \rightarrow Mn^{2+}(aq)$$

	Electrons	**H^+ ions**	**H_2O**
A.	reactant side	reactant side	product side
B.	reactant side	product side	reactant side
C.	product side	reactant side	product side
D.	product side	product side	reactant side

31. What are the correct names for $KMnO_4$ and $K_2Cr_2O_7$, using oxidation numbers?

A. Potassium permanganate and potassium dichromate

B. Potassium manganate(IV) and potassium chromate(VII)

C. Potassium permanganate(IV) and potassium dichromate(VII)

D. Potassium manganate(VII) and potassium dichromate(VI)

32. What is an industrial use of electrolysis?

A. The production of graphite

B. The production of iron

C. The production of electric energy

D. Electroplating

33. The overall equation of a voltaic cell is:

$$Ni(s) + 2Ag^{+}(aq) \rightleftharpoons Ni^{2+}(aq) + 2Ag(s) \qquad E^{\ominus} = 1.06\,V$$

The standard electrode potential for $Ni^{2+}(aq) + 2e^{-} \rightleftharpoons Ni(s)$, is $-0.26\,V$. What is the standard electrode potential for the silver half-cell, $Ag^{+}(aq) + e^{-} \rightleftharpoons Ag(s)$, in V?

A. –1.32

B. –0.80

C. +0.80

D. +1.32

34. What is the IUPAC name for $(CH_3)_2COH(CH_2)_2CH_3$?

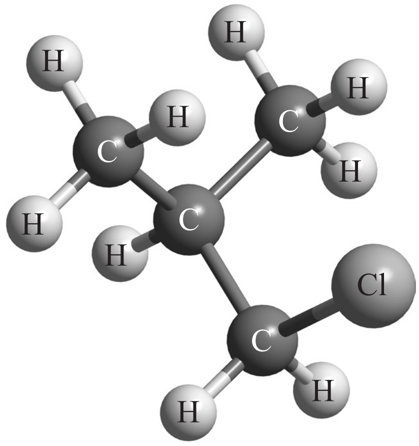
A. Hexan-3-ol

B. 2-methylpentan-2-ol

C. 2-methylpentan-3-ol

D. Dimethylpentan-1-ol

35. Which type of halogenoalkane is the substance shown below, and which type of nucleophilic reaction does it undergo with an aqueous sodium hydroxide solution?



	Type of halogenoalkane	**Type of nucleophilic reaction**
A.	primary	S_N1
B.	tertiary	S_N1
C.	primary	S_N2
D.	tertiary	S_N2

36. Which reaction produces **only** butan-2-ol?

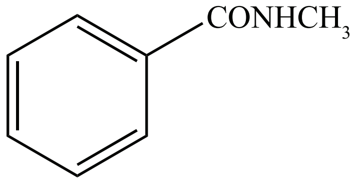
A. Addition of water to but-2-ene

B. Addition of water to but-1-ene

C. Reaction of 2-bromobutane with alcoholic sodium hydroxide

D. Reaction of 1-bromobutane with alcoholic sodium hydroxide

37. Which functional groups are present in $C_6H_5CONHCH_3$?



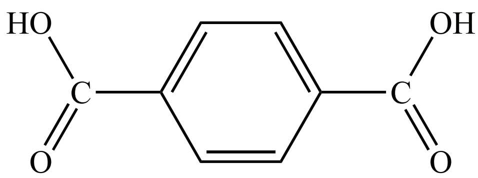
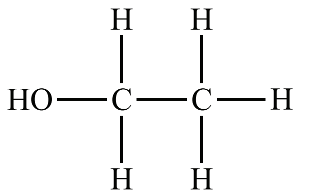
A. amide and benzene ring (phenyl)

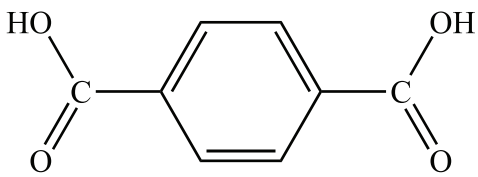
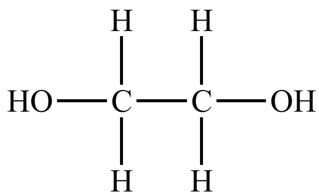
B. amine, benzene ring (phenyl) and carbonyl

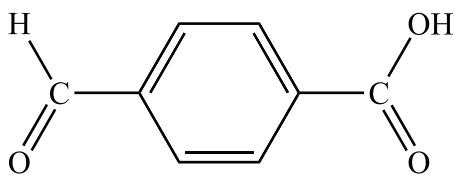
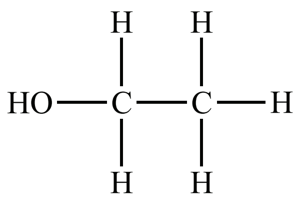
C. benzene ring (phenyl) and carbonyl

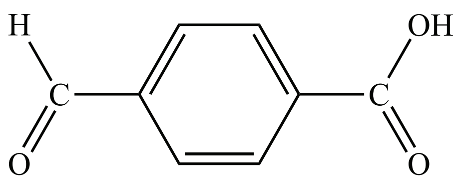
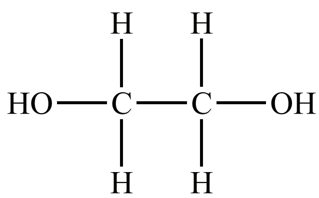
D. amine and benzene ring (phenyl)

38. Which two compounds can form a polyester?

A.  and 

B.  and 

C.  and 

D.  and 

39. Which statement about isomerism is correct?

A. But-1-ene and but-2-ene are geometrical isomers.

B. But-1-ene has two geometrical isomers.

C. Butan-1-ol and butan-2-ol are optical isomers.

D. Butan-2-ol has two optical isomers.

40. A student carries out a titration three times and obtains the following volumes: $3.0 \pm 0.1\,cm^3$, $3.2 \pm 0.1\,cm^3$ and $3.2 \pm 0.1\,cm^3$. What is the average volume?

A. $3.1 \pm 0.1\,cm^3$

B. $3.13 \pm 0.1\,cm^3$

C. $3.1 \pm 0.3\,cm^3$

D. $3.13 \pm 0.3\,cm^3$