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International Baccalaureate®
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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

1	2	3	4	5	6	7	0										
1 H 1.01		Atomic number Element						2 He 4.00									
3 Li 6.94	4 Be 9.01	Relative atomic mass					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
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‡	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)
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1. What is the mass, in g, of one mole of hydrated copper(II) sulfate, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, given the following relative atomic mass values?

Element	Cu	S	H	O
Relative atomic mass	64	32	1	16

- A. 160
 B. 178
 C. 186
 D. 250
2. An excess of calcium carbonate is added to a solution containing 0.10 mol of $\text{HCl}(\text{aq})$. What mass of calcium carbonate reacts, and what mass of carbon dioxide is formed?

Mass of one mole of $\text{CaCO}_3 = 100 \text{ g}$

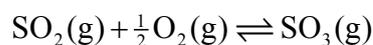
Mass of one mole of $\text{CO}_2 = 44 \text{ g}$



	$\text{CaCO}_3(\text{s}) / \text{g}$	$\text{CO}_2(\text{g}) / \text{g}$
A.	10	4.4
B.	10	2.2
C.	5.0	2.2
D.	5.0	4.4

3. For which compounds is the empirical formula the same as the molecular formula?
- I. Methane
 - II. Ethene
 - III. Ethanol
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III
4. What is the abbreviated electron configuration of the cobalt(II) ion, Co^{2+} ?
- A. $[\text{Ar}] 3d^7$
 - B. $[\text{Ar}] 4s^2 3d^5$
 - C. $[\text{Ar}] 4s^2 3d^7$
 - D. $[\text{Ar}] 4s^1 3d^6$
5. Which statement correctly describes the atomic emission spectrum of hydrogen?
- A. It is a continuous spectrum converging at high frequency.
 - B. It is a line spectrum converging at high frequency.
 - C. It is a continuous spectrum converging at low frequency.
 - D. It is a line spectrum converging at low frequency.

6. Which equation represents the second ionization energy of potassium?
- A. $\text{K(g)} \rightarrow \text{K}^{2+}(\text{g}) + 2\text{e}^{-}$
- B. $\text{K}^{+}(\text{g}) \rightarrow \text{K}^{2+}(\text{g}) + \text{e}^{-}$
- C. $\text{K(s)} \rightarrow \text{K}^{2+}(\text{g}) + 2\text{e}^{-}$
- D. $\text{K}^{+}(\text{s}) \rightarrow \text{K}^{2+}(\text{g}) + \text{e}^{-}$
7. Which pair of elements shows the greatest difference in electronegativity?
- A. Mg and O
- B. Li and F
- C. K and F
- D. Li and I
8. Which statements explain why a catalyst is used in the Contact process (shown below)?



- I. A catalyst lowers the activation energy.
- II. A catalyst moves the position of equilibrium towards the product.
- III. A catalyst allows the same rate to be achieved at a lower temperature.
- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

9. Which properties do typical ionic compounds have?

	Melting point	Conductivity of solid
A.	high	good
B.	low	good
C.	high	poor
D.	low	poor

10. What is the difference between the strength and the length of the carbon-oxygen bond in butanal and in butan-1-ol?

- A. The bond in butanal is stronger and longer than in butan-1-ol.
- B. The bond in butanal is weaker and shorter than in butan-1-ol.
- C. The bond in butanal is weaker and longer than in butan-1-ol.
- D. The bond in butanal is stronger and shorter than in butan-1-ol.

11. Which allotropes of carbon show sp^2 hybridization?

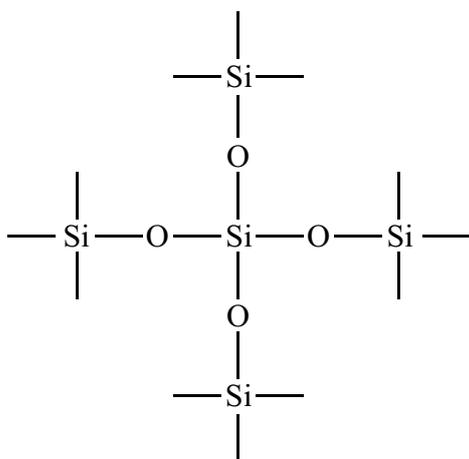
- I. Diamond
 - II. Graphite
 - III. C_{60} fullerene
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

12. Which molecule is trigonal bipyramidal in shape?

- A. PCl_3
- B. SiCl_4
- C. PCl_5
- D. SF_6

13. Which diagram represents the bonding in SiO_2 ?

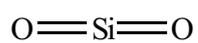
A.



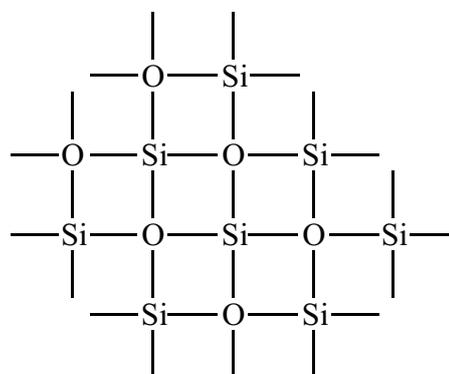
B.



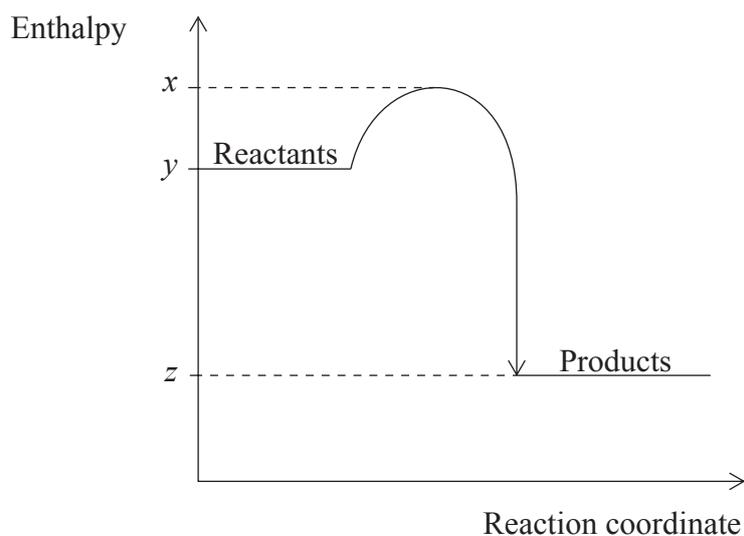
C.



D.



14. What is the value of ΔH for the exothermic reaction represented by the diagram below?



- A. $y - z$
- B. $z - y$
- C. $x - z$
- D. $z - x$
15. Which combination of enthalpy change and entropy change produces a non-spontaneous reaction at **all** temperatures?

	ΔH	ΔS
A.	+	-
B.	+	+
C.	-	-
D.	-	+

16. Which equation represents the lattice enthalpy of calcium chloride?
- A. $\text{CaCl(s)} \rightarrow \text{Ca}^+(\text{g}) + \text{Cl}^-(\text{g})$
- B. $\text{CaCl}_2(\text{s}) \rightarrow \text{Ca}^{2+}(\text{g}) + 2\text{Cl}^-(\text{g})$
- C. $\text{CaCl}_2(\text{g}) \rightarrow \text{Ca}^{2+}(\text{g}) + 2\text{Cl}^-(\text{g})$
- D. $\text{CaCl}_2(\text{s}) \rightarrow \text{Ca}^{2+}(\text{aq}) + 2\text{Cl}^-(\text{aq})$
17. In which reaction will the entropy of the system increase significantly?
- A. $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$
- B. $\text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$
- C. $\text{HCl}(\text{g}) + \text{NH}_3(\text{g}) \rightarrow \text{NH}_4\text{Cl}(\text{s})$
- D. $\text{NaOH}(\text{aq}) + \text{HCl}(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
18. Which equation represents the second electron affinity of oxygen?
- A. $\frac{1}{2}\text{O}_2(\text{g}) + 2\text{e}^- \rightarrow \text{O}^{2-}(\text{g})$
- B. $\text{O}(\text{g}) + 2\text{e}^- \rightarrow \text{O}^{2-}(\text{g})$
- C. $\text{O}_2(\text{g}) + 4\text{e}^- \rightarrow 2\text{O}^{2-}(\text{g})$
- D. $\text{O}^-(\text{g}) + \text{e}^- \rightarrow \text{O}^{2-}(\text{g})$
19. What is the temperature rise when 2100 J of energy is supplied to 100 g of water? (Specific heat capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$.)
- A. 5°C
- B. 278 K
- C. 0.2°C
- D. 20°C

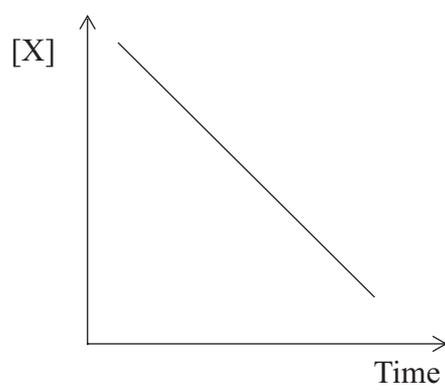
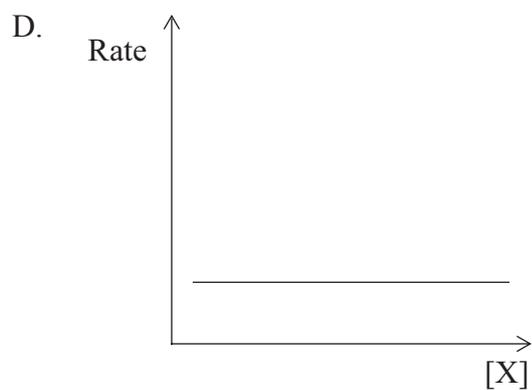
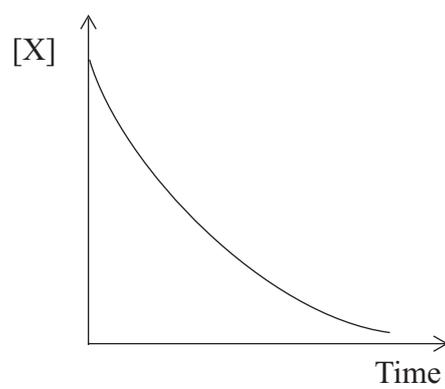
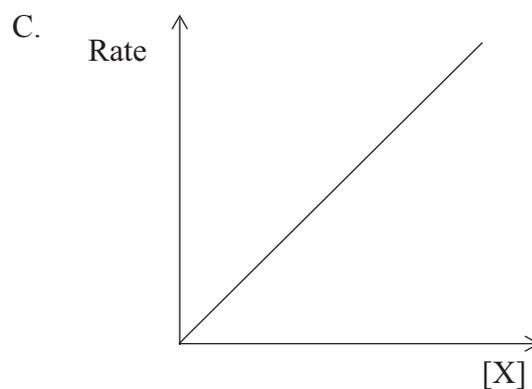
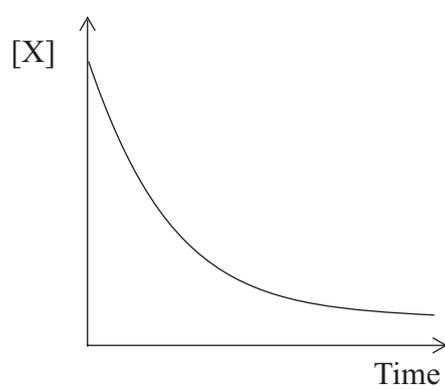
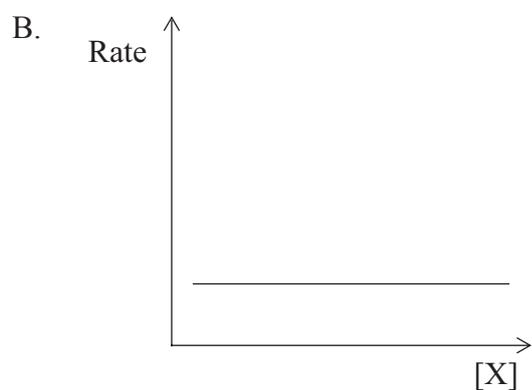
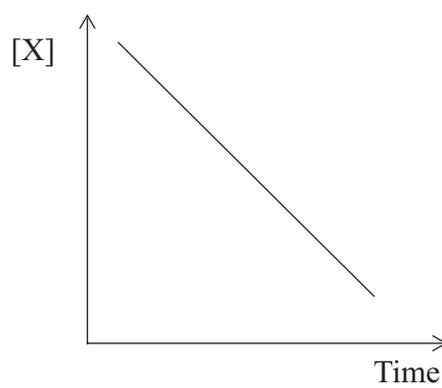
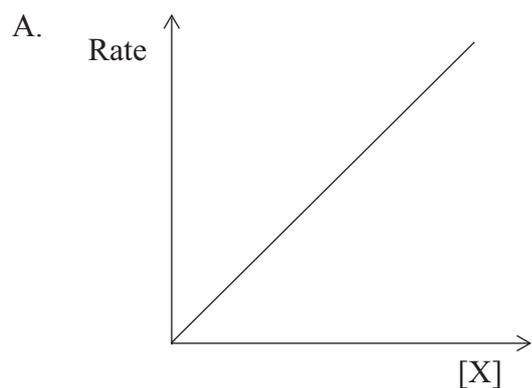
20. Which is **not** affected by an increase in temperature?

- A. Rate of reaction
- B. Collision frequency
- C. Collision geometry
- D. % of molecules with $E \geq E_a$

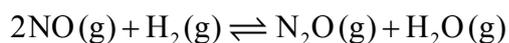
21. Which combination shows a second-order rate expression with the correct rate constant units?

	Rate expression	<i>k</i> units
A.	rate = $k[\text{NH}_3][\text{BF}_3]$	$\text{mol dm}^{-3} \text{s}^{-1}$
B.	rate = $k[\text{N}_2\text{O}_5]$	s^{-1}
C.	rate = $k[\text{N}_2\text{O}_5]$	$\text{dm}^3 \text{mol}^{-1} \text{s}^{-1}$
D.	rate = $k[\text{CH}_3\text{COCH}_3][\text{H}^+][\text{I}_2]^0$	$\text{dm}^3 \text{mol}^{-1} \text{s}^{-1}$

22. Which pair of graphs shows a decomposition reaction of X that obeys first-order kinetics?



23. What is the equilibrium constant expression, K_c , for this reaction?



- A. $K_c = \frac{[\text{N}_2\text{O}] + [\text{H}_2\text{O}]}{2[\text{NO}] + [\text{H}_2]}$
- B. $K_c = \frac{[\text{NO}]^2 [\text{H}_2]}{[\text{N}_2\text{O}][\text{H}_2\text{O}]}$
- C. $K_c = \frac{[2\text{NO}] + [\text{H}_2]}{[\text{N}_2\text{O}] + [\text{H}_2\text{O}]}$
- D. $K_c = \frac{[\text{N}_2\text{O}][\text{H}_2\text{O}]}{[\text{NO}]^2 [\text{H}_2]}$

24. Which combination of properties is correct?

	Enthalpy of vaporization	Boiling point	Intermolecular forces	Volatility
A.	large	high	strong	low
B.	large	low	weak	high
C.	small	low	weak	low
D.	small	high	weak	low

25. Which compound reacts with calcium oxide, CaO?

- A. K_2O
- B. Na_2O
- C. SO_2
- D. MgO

26. What is the conjugate base of phenol, C_6H_5OH ?
- A. $C_6H_4^-—OH$
- B. $C_6H_5—\overset{+}{O}H_2$
- C. $C_6H_5—O^-$
- D. $C_6H_6^+—OH$
27. Which compounds can be mixed together as aqueous solutions of equal volume and concentration to form an acidic buffer solution?
- A. Sodium hydrogensulfate and sulfuric acid
- B. Sodium propanoate and propanoic acid
- C. Ammonium chloride and ammonia solution
- D. Sodium chloride and hydrochloric acid
28. Which statements about an acid–base indicator are correct?
- I. It can be a weak acid.
- II. It is a substance in which the conjugate acid/base pair are different colours.
- III. It can be a weak base.
- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

29. What is the expression for the ionic product constant of water, K_w ?

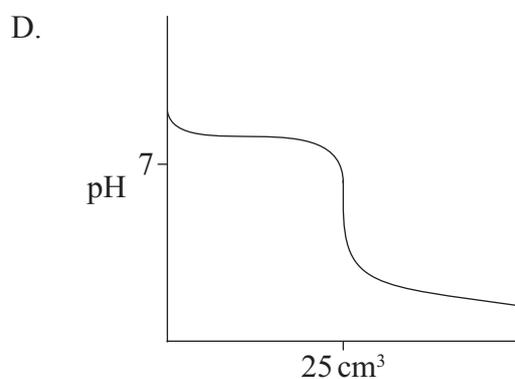
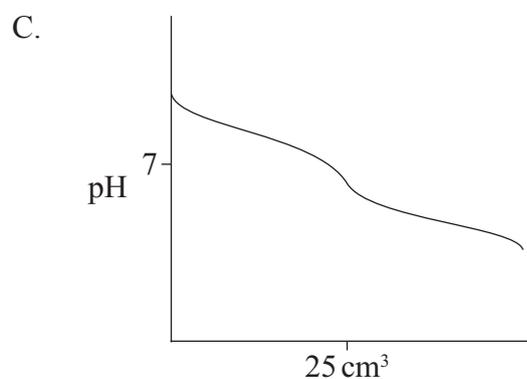
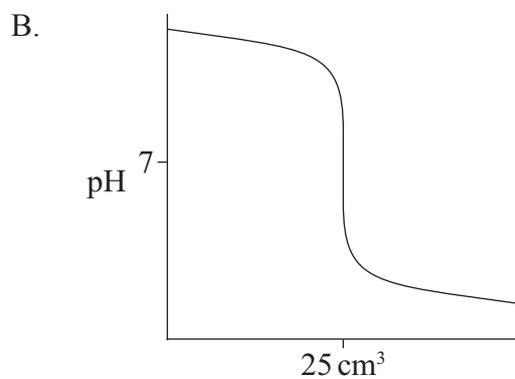
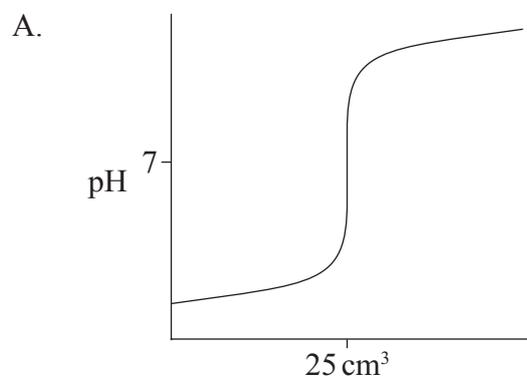
A. $K_w = K_a \times K_b$

B. $K_w = K_a + K_b$

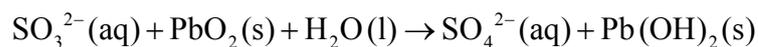
C. $K_w = \frac{K_a}{K_b}$

D. $K_w = K_a - K_b$

30. Which graph would be obtained by adding $0.10 \text{ mol dm}^{-3} \text{ HCl(aq)}$ to 25 cm^3 of $0.10 \text{ mol dm}^{-3} \text{ NaOH(aq)}$?

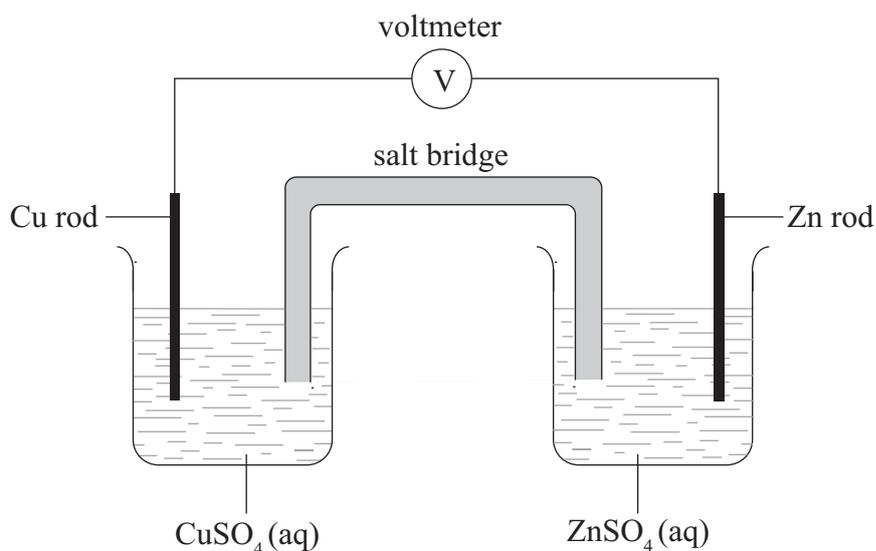


31. Which species are the oxidizing and reducing agents in the following reaction?



	Oxidizing agent	Reducing agent
A.	PbO_2	H_2O
B.	SO_3^{2-}	PbO_2
C.	H_2O	SO_3^{2-}
D.	PbO_2	SO_3^{2-}

32. Zinc is more reactive than copper. In this voltaic cell, which species is reduced and in which direction do negative ions flow in the salt bridge?

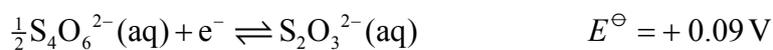
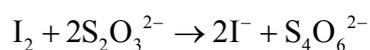


	Species reduced	Direction of negative ion flow in salt bridge
A.	Cu^{2+}	from copper half-cell to zinc half-cell
B.	Cu^{2+}	from zinc half-cell to copper half-cell
C.	Zn^{2+}	from copper half-cell to zinc half-cell
D.	Zn^{2+}	from zinc half-cell to copper half-cell

33. Which components are used to make the standard hydrogen electrode?

- A. $\text{H}_2(\text{g})$, $\text{H}^+(\text{aq})$, $\text{Pt}(\text{s})$
- B. $\text{H}_2(\text{g})$, $\text{H}^+(\text{aq})$, $\text{Ni}(\text{s})$
- C. $\text{H}_2(\text{g})$, $\text{HO}^-(\text{aq})$, $\text{Pt}(\text{s})$
- D. $\text{H}_2(\text{g})$, $\text{HO}^-(\text{aq})$, $\text{Ni}(\text{s})$

34. What is the cell potential, in V, of the reaction below?



- A. +0.63
 - B. +0.45
 - C. -0.45
 - D. -0.63
35. In organic reaction mechanisms, what does a curly arrow represent?
- A. The movement of a pair of electrons towards a nucleophile
 - B. The movement of a pair of electrons towards a positively charged species
 - C. The movement of a pair of electrons away from a positively charged species
 - D. The movement of a pair of electrons towards a Lewis base

36. Which properties are features of a homologous series?

- I. Same general formula
- II. Similar chemical properties
- III. Gradation in physical properties

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

37. What does a polarimeter measure?

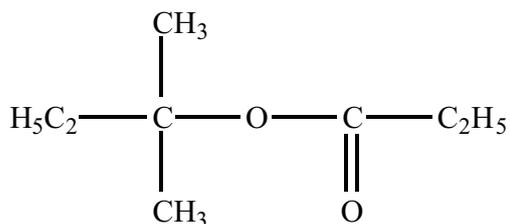
- A. Colour of reaction mixture
- B. Polarity of a molecule
- C. Configuration of a molecule as R or S
- D. Rotation of plane-polarized light

38. Which compound can exist as stereoisomers?

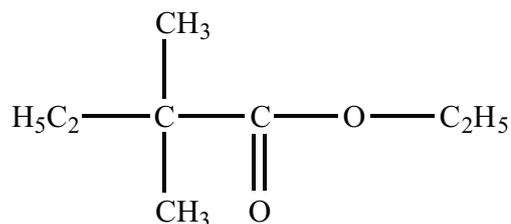
- A. 1,2-dichloroethane
- B. 1,1-dichloroethene
- C. Butan-2-ol
- D. Propan-2-ol

39. What is the structural formula of the ester formed by reacting propanoic acid with 2-methylbutan-2-ol under appropriate conditions?

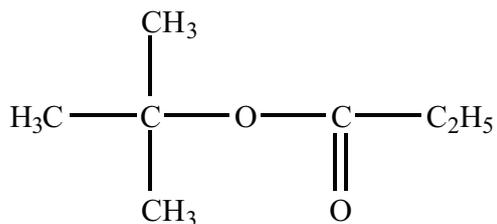
A.



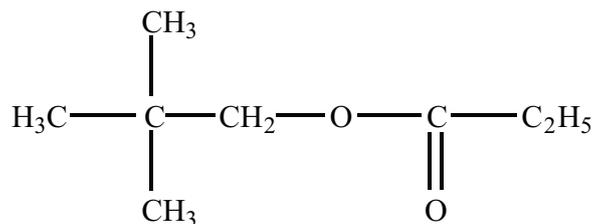
B.



C.



D.



40. Which statement about errors is correct?

- A. A random error is always expressed as a percentage.
- B. A systematic error can be reduced by taking more readings.
- C. A systematic error is always expressed as a percentage.
- D. A random error can be reduced by taking more readings.