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International Baccalaureate®
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CHEMISTRY
HIGHER LEVEL
PAPER 1

Thursday 16 May 2013 (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																	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. What is the whole number ratio of the coefficients of ammonia to oxygen when the following equation is balanced correctly?

$$\_\_\_\ NH_3(g) + \_\_\_\ O_2(g) \rightarrow \_\_\_\ NO(g) + \_\_\_\ H_2O(l)$$

A. 1 : 2

B. 2 : 1

C. 4 : 5

D. 5 : 4

2. When 50 cm^3 of a hydrocarbon, C_xH_y, was burned in excess oxygen, 200 cm^3 of carbon dioxide and 250 cm^3 of steam were produced (all volumes were measured under the same conditions). What is the molecular formula of the hydrocarbon?

A. C_2H_4

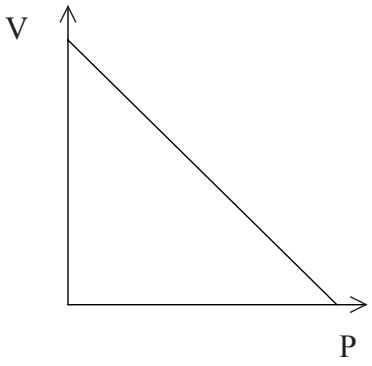
B. C_3H_8

C. C_4H_8

D. C_4H_{10}

3. Which graph represents the relationship between volume and pressure for a fixed mass of gas at constant temperature?

A.



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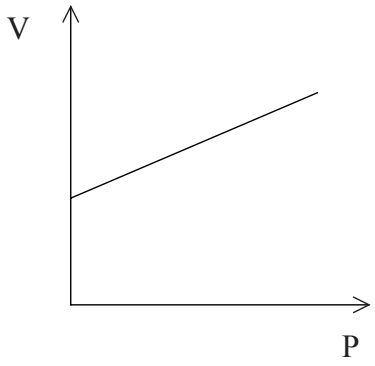

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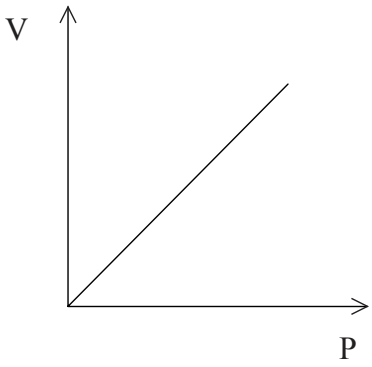

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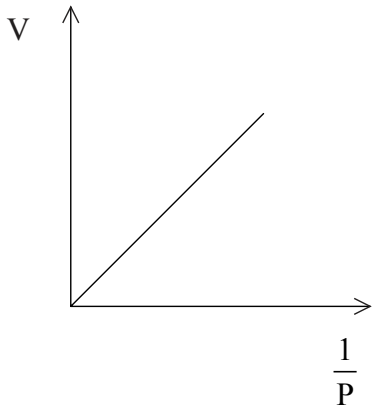
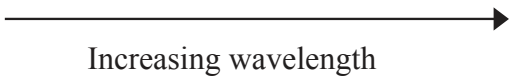
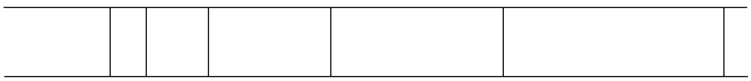


4. Which diagram shows a pattern similar to the emission spectrum of hydrogen?



A.

B.



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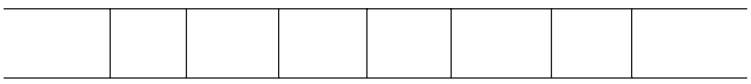
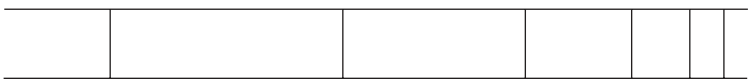


D.



5. What is the correct electron configuration of the Cu^+ ion?

A. [Ar] $3d^9\ 4s^1$

B. [Ar] $3d^7\ 4s^2$

C. [Ar] $3d^{10}$

D. [Ar] $3d^8\ 4s^1$

6. Which statement concerning electronegativity is correct?

A. Electronegativity increases from left to right across a period.

B. Metals generally have higher electronegativity values than non-metals.

C. Electronegativity increases on descending a group.

D. Noble gases have the highest electronegativity values.

7. Which statements are correct?

I. Fluorine will react with potassium chloride solution to produce chlorine.

II. Iodine will react with sodium chloride solution to produce chlorine.

III. Bromine will react with lithium iodide solution to produce iodine.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

8. Each of the following oxides is added to separate equal volumes of distilled water. Which of the following is the most acidic oxide?

A. P_4O_{10}

B. SO_3

C. Cl_2O_7

D. SiO_2

9. What are the correct formulas of the following ions?

	Nitrate	Sulfate	Phosphate	Hydrogencarbonate
A.	NO_3^-	SO_4^{2-}	PO_4^{3-}	HCO_3^-
B.	NO_3^-	SO_4^{2-}	PO_3^{3-}	HCO_3^{2-}
C.	NO_2^-	SO_4^-	PO_4^{3-}	HCO_3^-
D.	NO_2^-	SO_3^{2-}	PO_3^{3-}	HCO_3^{2-}

10. Which compound is predominantly covalent?

A. LiCl

B. Al_2O_3

C. ClF

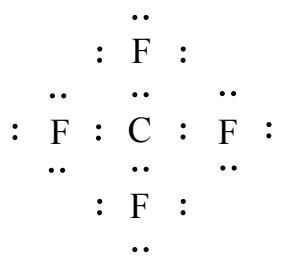
D. $ZnCl_2$

11. Which combination best describes the type of bonding present and the melting point of silicon and silicon dioxide?

	Silicon		Silicon dioxide	
A.	covalent bonding	high melting point	covalent bonding	high melting point
B.	metallic bonding	high melting point	covalent bonding	low melting point
C.	ionic bonding	high melting point	ionic bonding	low melting point
D.	covalent bonding	low melting point	ionic bonding	high melting point

12. Which species has a square planar shape?

A.



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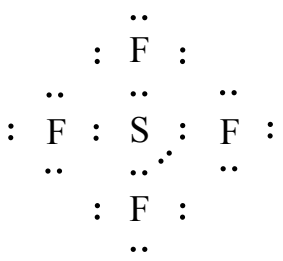

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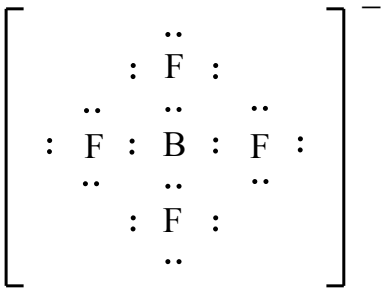

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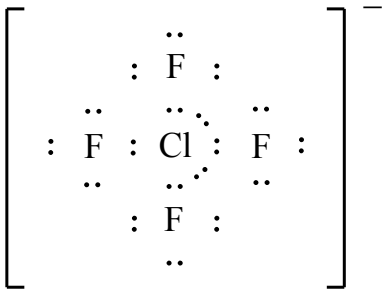
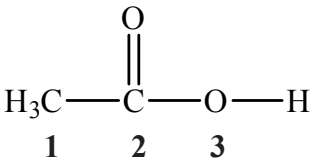
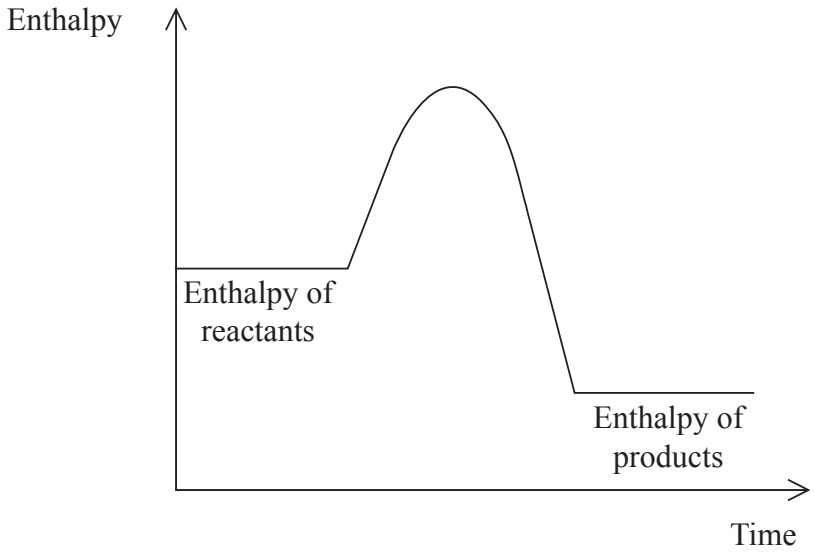


13. What are the hybridizations of the atoms labelled **1**, **2** and **3** in the molecule below?



	1	2	3
A.	sp^2	sp^2	sp
B.	sp^3	sp^2	sp^3
C.	sp^2	sp	sp^3
D.	sp^3	sp^2	sp

14. Which statement is correct for the enthalpy level diagram shown?



A. The reaction is exothermic and the products are more stable than the reactants.

B. The reaction is exothermic and the sign of the enthalpy change is positive.

C. The reaction is endothermic and the sign of the enthalpy change is negative.

D. The reaction is endothermic and the products are more stable than the reactants.

15. Which process is endothermic?

A. $2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$

B. $Na(g) \rightarrow Na^+(g) + e^-$

C. $H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$

D. $NH_3(g) \rightarrow NH_3(l)$

16. Which combination of ions will give the greatest absolute lattice enthalpy?

A. A small positive ion with a high charge and a small negative ion with a high charge

B. A small positive ion with a low charge and a small negative ion with a low charge

C. A large positive ion with a high charge and a large negative ion with a high charge

D. A large positive ion with a low charge and a small negative ion with a low charge

17. Which process would be expected to have a $\Delta S^\ominus$ value which is negative?

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

B. $NaCl(s) \rightarrow Na^+(g) + Cl^-(g)$

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

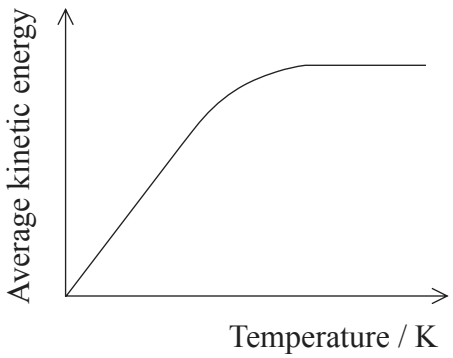
D. $OF_2(g) + H_2O(g) \rightarrow O_2(g) + 2HF(g)$

18. When solid potassium chlorate, $KClO_3$, dissolves in distilled water the temperature of the solution decreases. What are the signs of $\Delta H^\ominus$, $\Delta S^\ominus$ and $\Delta G^\ominus$ for this spontaneous process?

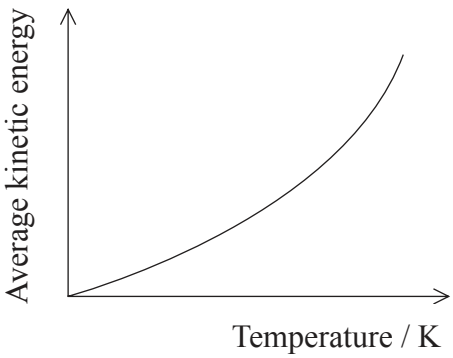
	$\Delta H^\ominus$	$\Delta S^\ominus$	$\Delta G^\ominus$
A.	+	+	+
B.	+	+	–
C.	–	–	–
D.	+	–	+

19. Which graph best represents the relationship between the average kinetic energy of molecules of a gas and temperature in K?

A.



B.



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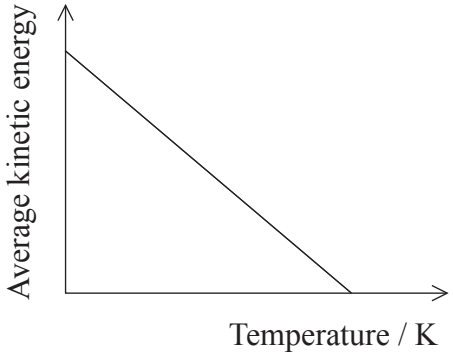
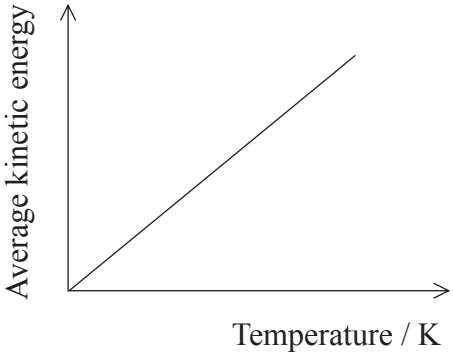


D.



20. For the gas phase reaction:

$$A(g) + B(g) \rightarrow C(g)$$

the experimentally determined rate expression is: rate = k [A] $[B]^2$

By what factor will the rate change if the concentration of A is tripled and the concentration of B is halved?

A. 0.75

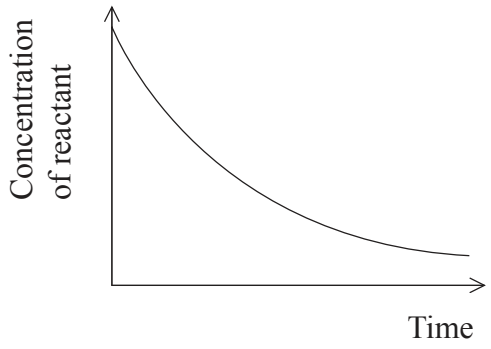
B. 1.5

C. 6

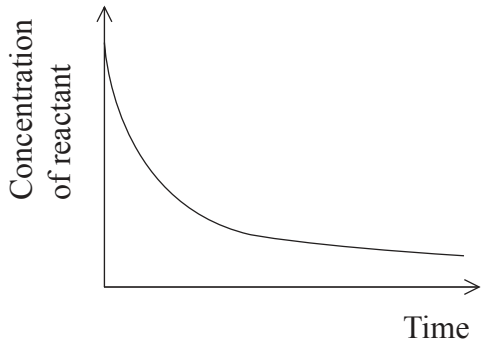
D. 12

21. Which graph best represents a second-order reaction?

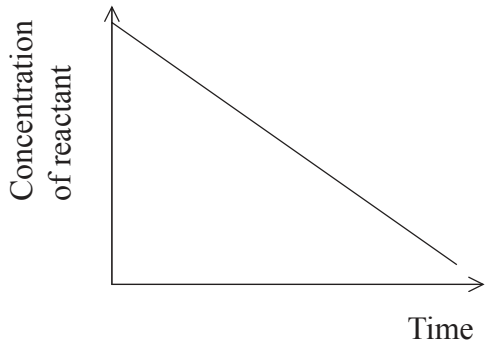
A.



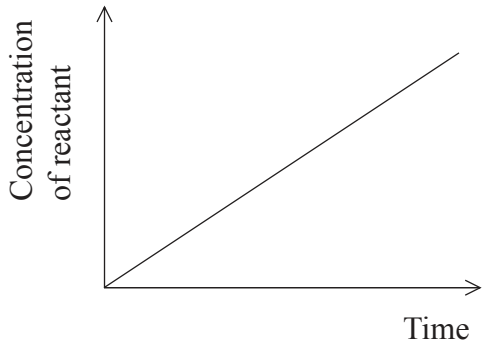
B.



C.



D.



22. Which changes occur when the temperature is decreased in the following equilibrium?

$$2BrCl(g) \rightleftharpoons Br_2(g) + Cl_2(g) \qquad \Delta H^{\ominus} = -14\,kJ$$

	Position of equilibrium	**Value of K_c**
A.	shifts to the right	decreases
B.	shifts to the right	increases
C.	shifts to the left	decreases
D.	shifts to the left	increases

23. When gaseous nitrosyl chloride, $NOCl(g)$, decomposes, the following equilibrium is established:

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$$

2.0 mol of $NOCl(g)$ were placed in a 1.0 dm^3 container and allowed to reach equilibrium. At equilibrium 1.0 mol of $NOCl(g)$ was present. What is the value of K_c?

A. 0.50

B. 1.0

C. 1.5

D. 2.0

24. In which equilibria are the conjugate acid–base pairs correctly labelled?

I. $CO_3^{2-}(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + OH^-(aq)$
Base 1 Acid 2 Acid 1 Base 2

II. $HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq) + OH^-(aq)$
Base 1 Acid 2 Acid 1 Base 2

III. $NH_4^+(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + NH_3(aq)$
Acid 1 Base 2 Acid 2 Base 1

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

25. A solution of acid HX has a pH = 1 and a solution of acid HY has a pH = 3. Which statement **must** be correct?

A. HX is a stronger acid than HY.

B. HY is a stronger acid than HX.

C. The $[H^+]$ in the solution of HX is 100 times greater than the $[H^+]$ in the solution of HY.

D. The $[H^+]$ in the solution of HY is 100 times greater than the $[H^+]$ in the solution of HX.

26. The values of K_w, the ionic product constant of water, are:

K_w	**T / °C**
6.4×10^{-15}	18
1.0×10^{-14}	25

Which statements are correct?

I. The $[OH^-]$ in water is less than the $[H^+]$ at 18 °C.

II. The ionization of water is an endothermic process.

III. The pH of water is lower at 25 °C than at 18 °C.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

27. For which equilibrium can an expression for a base dissociation constant, K_b, for the forward reaction be written?

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

B. $F^- + H_2O \rightleftharpoons HF + OH^-$

C. $NH_4^+ + OH^- \rightleftharpoons NH_3 + H_2O$

D. $HF + OH^- \rightleftharpoons H_2O + F^-$

28. Which of the following mixtures, in an aqueous solution, will produce a buffer solution?

I. $50\,cm^3$ of $0.1\,mol\,dm^{-3}$ CH_3COONa and $50\,cm^3$ of $0.1\,mol\,dm^{-3}$ CH_3COOH

II. $50\,cm^3$ of $0.1\,mol\,dm^{-3}$ NH_3 and $50\,cm^3$ of $0.1\,mol\,dm^{-3}$ NH_4Cl

III. $50\,cm^3$ of $0.1\,mol\,dm^{-3}$ NaOH and $50\,cm^3$ of $0.2\,mol\,dm^{-3}$ CH_3COOH

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

29. The colours of three indicators are shown in the table below.

Indicator	Colour at low pH	Colour at high pH	pH range at which colour change takes place
methyl orange	red	yellow	3.2–4.4
bromothymol blue	yellow	blue	6.0–7.6
phenolphthalein	colourless	pink	8.2–10.0

Equal volumes of these three indicators were mixed and the mixture was added to a solution of pH = 5.0. What colour would be seen?

A. Yellow

B. Orange

C. Green

D. Blue

30. Which statement is correct about a reducing agent?

A. It is reduced by gaining electrons.

B. It is oxidized by gaining electrons.

C. It is oxidized by losing electrons.

D. It is reduced by losing electrons.

31. An aqueous solution of a metal salt is electrolysed. Which factor will have no effect on the mass of the metal deposited on the negative electrode (cathode), if all other variables remain constant?

A. Size of metal ion

B. Relative atomic mass of metal

C. Current

D. Charge on metal ion

32. Which are correct statements about a voltaic cell?

I. A spontaneous redox reaction occurs which converts chemical energy to electrical energy.

II. Oxidation occurs at the negative electrode (anode).

III. Electricity is conducted by the movement of electrons through the salt bridge.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

33. The standard electrode potentials of some half-reactions are given below.

$$Sn^{4+}(aq) + 2e^- \rightleftharpoons Sn^{2+}(aq) \qquad E^{\ominus} = +0.15 \text{ V}$$

$$\tfrac{1}{2}I_2(s) + e^- \rightleftharpoons I^-(aq) \qquad E^{\ominus} = +0.54 \text{ V}$$

$$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq) \qquad E^{\ominus} = +0.77 \text{ V}$$

Which of the following reactions will occur spontaneously?

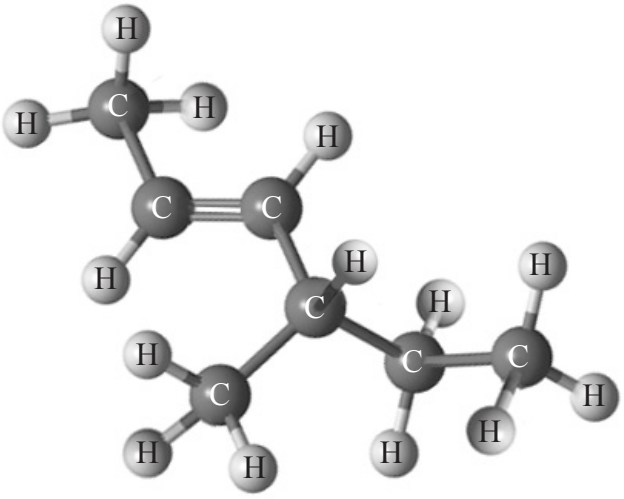
A. Iodine reduces Fe^{3+} to Fe^{2+}

B. Iodine reduces Sn^{4+} to Sn^{2+}

C. Iodine oxidizes Fe^{2+} to Fe^{3+}

D. Iodine oxidizes Sn^{2+} to Sn^{4+}

34. What is the name of the following compound applying IUPAC rules?



A. *cis*-4-methylhex-2-ene

B. *cis*-4-ethylpent-2-ene

C. *trans*-4-methylhex-2-ene

D. *trans*-4-ethylpent-2-ene

35. Which steps are involved in the free-radical mechanism of the bromination of ethane in the presence of ultraviolet radiation?

I. $C_2H_6 + Br\bullet \rightarrow C_2H_5\bullet + HBr$

II. $C_2H_5\bullet + Br_2 \rightarrow C_2H_5Br + Br\bullet$

III. $C_2H_5\bullet + Br\bullet \rightarrow C_2H_5Br$

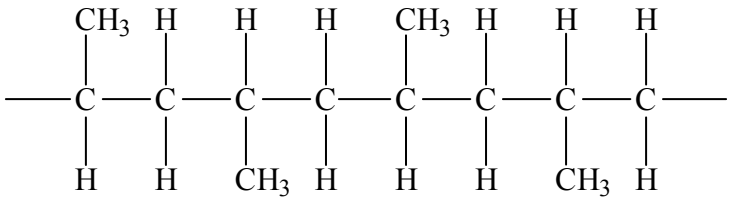
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

36. Which substance can be polymerized to produce the polymer below?



A. But-1-ene

B. But-2-ene

C. Propene

D. 2-methylpropene

37. Which factors affect the rate of nucleophilic substitution in halogenoalkanes?

I. The nature of the attacking nucleophile

II. The identity of the halogen

III. The structure of the halogenoalkane

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

38. Which molecule exhibits optical isomerism?

A. 3-chloropentane

B. 2-chlorobutane

C. 1,3-dichloropropane

D. 2-chloro-2-methylpropane

39. What is a use of the organic product formed when an alcohol and a carboxylic acid react together?

A. Pesticide

B. Lubricant

C. Flavourings in food

D. Fertilizer

40. Which would be the best method to decrease the random uncertainty of a measurement in an acid–base titration?

A. Ensure your eye is at the same height as the meniscus when reading the burette.

B. Use a different indicator for the titration.

C. Use a different burette.

D. Repeat the titration.
