Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Higher level
Paper 1

Wednesday 16 May 2018 (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]**.

2218 – 6113

19 pages

The Periodic Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 **H** 1.01			Atomic number **Element** Relative atomic mass														2 **He** 4.00
2	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
3	11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.90
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.96	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
6	55 **Cs** 132.91	56 **Ba** 137.33	57 † **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** (226)	89 ‡ **Ac** (227)	104 **Rf** (267)	105 **Db** (268)	106 **Sg** (269)	107 **Bh** (270)	108 **Hs** (269)	109 **Mt** (278)	110 **Ds** (281)	111 **Rg** (281)	112 **Cn** (285)	113 **Unt** (286)	114 **Uug** (289)	115 **Uup** (288)	116 **Uuh** (293)	117 **Uus** (294)	118 **Uuo** (294)

†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

1. What is the number of atoms of oxygen in 2.0 mol of hydrated sodium carbonate, $Na_2CO_3 \cdot 10H_2O$? Avogadro's constant, L or N_A : $6.02 \times 10^{23}\,mol^{-1}$

A. 6

B. 26

C. 3.6×10^{24}

D. 1.6×10^{25}

2. What is the volume, in cm^3, of the final solution if 100 cm^3 of a solution containing 1.42 g of sodium sulfate, Na_2SO_4, is diluted to the concentration of 0.020 mol dm^{-3}?
M_r (Na_2SO_4) = 142

A. 50

B. 400

C. 500

D. 600

3. What is the percentage yield when 2.0 g of ethene, C_2H_4, is formed from 5.0 g of ethanol, C_2H_5OH?
M_r (ethene) = 28; M_r (ethanol) = 46

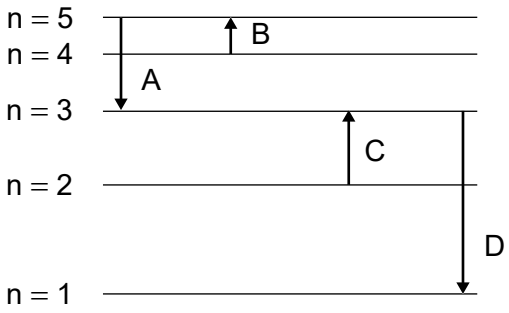
A. $\frac{2.0}{28} \times \frac{5.0}{46} \times 100$

B. $\frac{\frac{2.0}{28}}{\frac{5.0}{46}} \times 100$

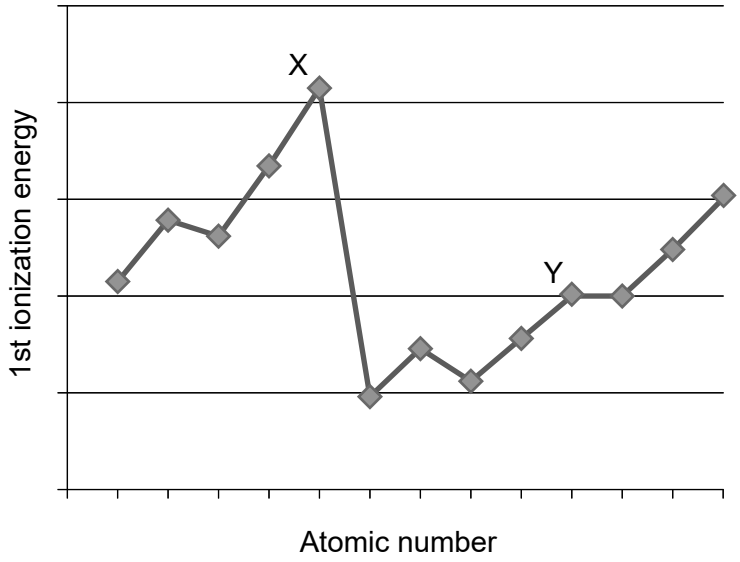
C. $\frac{28}{2.0} \times \frac{5.0}{46} \times 100$

D. $\frac{\frac{28}{2.0}}{\frac{5.0}{46}} \times 100$

4. Which electron transition emits energy of the longest wavelength?



5. The graph shows the first ionization energies of some consecutive elements.



Which statement is correct?

A. Y is in group 3

B. Y is in group 10

C. X is in group 5

D. X is in group 18

6. Which increase across a period from left to right?

A.	ionic radius	electronegativity
B.	atomic radius	ionic radius
C.	1st ionization energy	atomic radius
D.	1st ionization energy	electronegativity

7. Which element is in the p-block?

A. Pb

B. Pm

C. Pt

D. Pu

8. Part of the spectrochemical series is shown for transition metal complexes.

$$I^- < Cl^- < H_2O < NH_3$$

Which statement can be correctly deduced from the series?

A. H_2O increases the p–d separation more than Cl^-.

B. H_2O increases the d–d separation more than Cl^-.

C. A complex with Cl^- is more likely to be blue than that with NH_3.

D. Complexes with water are always blue.

9. What is the formula of magnesium nitride?

A. MgN

B. Mg_2N_3

C. Mg_3N

D. Mg_3N_2

10. Which species has the longest carbon to oxygen bond length?

A. CO

B. CH_3OH

C. $CH_3CO_2^-$

D. H_2CO

11. What are the predicted electron domain geometries around the carbon and both nitrogen atoms in urea, $(NH_2)_2CO$, applying VSEPR theory?

	Carbon atom	**Nitrogen atoms**
A.	trigonal planar	trigonal pyramidal
B.	trigonal planar	tetrahedral
C.	tetrahedral	tetrahedral
D.	trigonal pyramidal	trigonal planar

12. Which molecule has an expanded octet?

A. CO

B. CO_2

C. SF_2

D. SF_4

13. Which overlap of atomic orbitals leads to the formation of only a sigma (σ) bond?

I. s – p
II. p – p
III. s – s

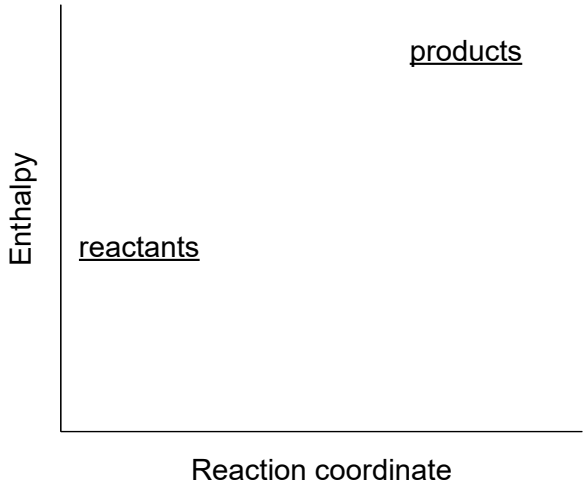
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

14. Which describes the reaction shown in the potential energy profile?



A. The reaction is endothermic and the products have greater enthalpy than the reactants.

B. The reaction is endothermic and the reactants have greater enthalpy than the products.

C. The reaction is exothermic and the products have greater enthalpy than the reactants.

D. The reaction is exothermic and the reactants have greater enthalpy than the products.

15. Two 100 cm^3 aqueous solutions, one containing 0.010 mol NaOH and the other 0.010 mol HCl, are at the same temperature.

When the two solutions are mixed the temperature rises by y °C.

Assume the density of the final solution is 1.00 g cm^{-3}.
Specific heat capacity of water = 4.18 J g^{-1} K^{-1}

What is the enthalpy change of neutralization in kJ mol^{-1}?

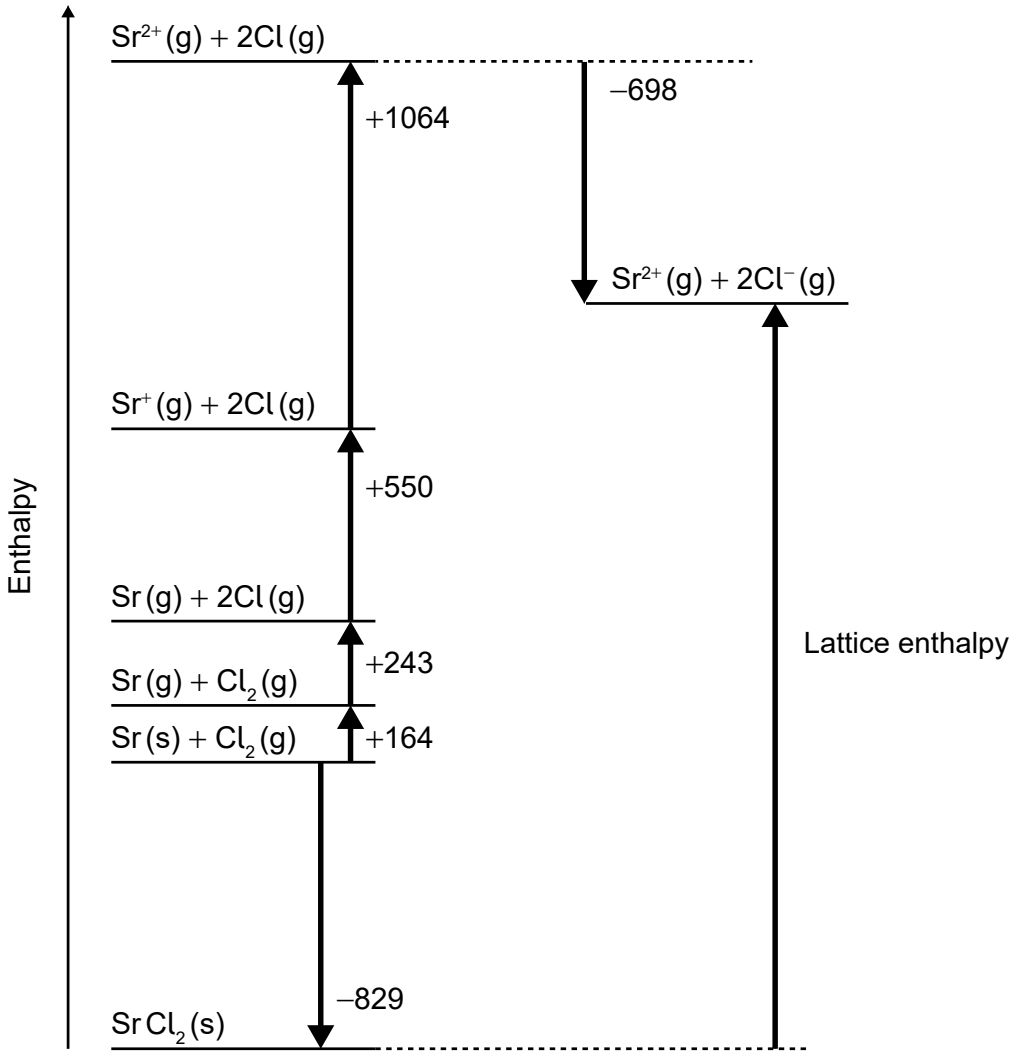
A. $\frac{200 \times 4.18 \times y}{1000 \times 0.020}$

B. $\frac{200 \times 4.18 \times y}{1000 \times 0.010}$

C. $\frac{100 \times 4.18 \times y}{1000 \times 0.010}$

D. $\frac{200 \times 4.18 \times (y + 273)}{1000 \times 0.010}$

16. Which value represents the lattice enthalpy, in kJ mol^{-1}, of strontium chloride, $SrCl_2$?



A. $-(-829) + 164 + 243 + 550 + 1064 - (-698)$

B. $-829 + 164 + 243 + 550 + 1064 - 698$

C. $-(-829) + 164 + 243 + 550 + 1064 - 698$

D. $-829 + 164 + 243 + 550 + 1064 - (-698)$

17. Which system has the most negative entropy change, ΔS, for the forward reaction?

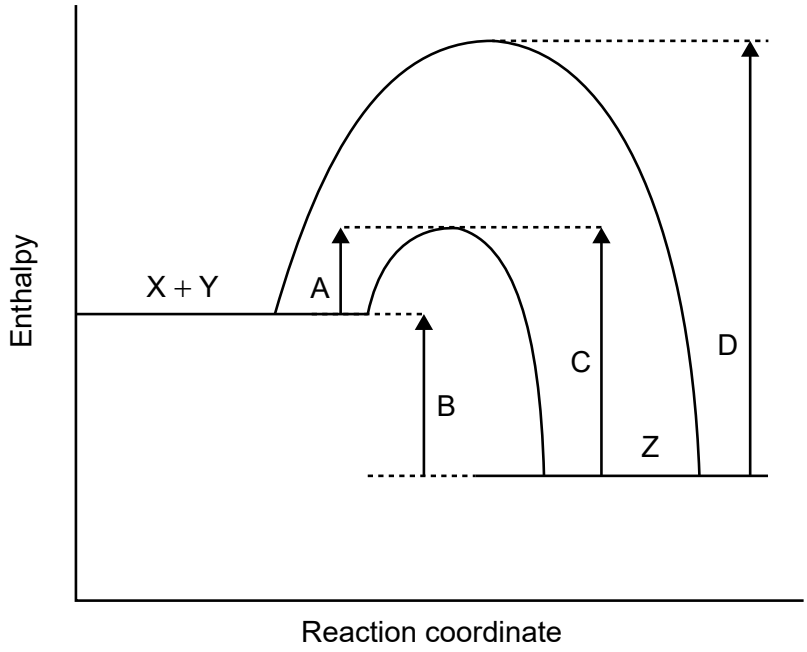
A. $N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$

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

C. $2S_2O_3^{2-}\,(aq) + I_2\,(aq) \rightarrow S_4O_6^{2-}\,(aq) + 2I^-\,(aq)$

D. $H_2O\,(l) \rightarrow H_2O\,(g)$

18. The potential energy profile for the reversible reaction, $X + Y \rightleftharpoons Z$ is shown.



Which arrow represents the activation energy for the reverse reaction, $Z \rightarrow X + Y$, with a catalyst?

19. Which factors can affect the rate of reaction?

I. Particle size of solid reactant
II. Concentration of reacting solution
III. Pressure of reacting gas

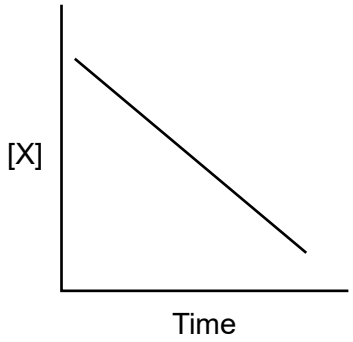
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

20. When X reacts with Y to give Z, the following graph is plotted. What can be deduced from the graph?



A. The concentration of X is directly proportional to time.

B. The reaction is first order overall.

C. The reaction is zero order with respect to X.

D. The reaction is first order with respect to X.

21. Which statement is correct?

A. The value of the rate constant, *k*, is independent of temperature and is deduced from the equilibrium constant, K_c.

B. The value of the rate constant, *k*, is independent of temperature and the overall reaction order determines its units.

C. The value of the rate constant, *k*, is temperature dependent and is deduced from the equilibrium constant, K_c.

D. The value of the rate constant, *k*, is temperature dependent and the overall reaction order determines its units.

22. Which factor does **not** affect the position of equilibrium in this reaction?

$$2NO_2\,(g) \rightleftharpoons N_2O_4\,(g) \qquad \Delta H = -58\,\text{kJ mol}^{-1}$$

A. Change in volume of the container

B. Change in temperature

C. Addition of a catalyst

D. Change in pressure

23. What occurs when the pressure on the given equilibrium is increased at constant temperature?

$$N_2\,(g) + O_2\,(g) \rightleftharpoons 2NO\,(g) \qquad \Delta H = +180\,kJ$$

A. K_c increases and the position of equilibrium moves to the right.

B. K_c stays the same and the position of equilibrium is unchanged.

C. K_c stays the same and the position of equilibrium moves to the left.

D. K_c decreases and the position of equilibrium moves to the left.

24. Activity series of selected elements:

K, Ca, Al, Fe, H, Cu, Ag, Au

greatest activity ⟵ least activity

Which react with dilute sulfuric acid?

I. Cu
II. CuO
III. $CuCO_3$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

25. Which statement is correct?

A. A strong acid is a good proton donor and has a strong conjugate base.

B. A weak acid is a poor proton acceptor and has a strong conjugate base.

C. A strong acid is a good proton donor and has a weak conjugate base.

D. A strong base is a good proton donor and has a weak conjugate acid.

26. Which is an example of a Lewis base?

A. an electrophile

B. BF_3

C. CH_4

D. a nucleophile

27. What is the order of increasing acidity?

Acid	pK_a
HClO	7.4
HIO_3	0.8

Acid	K_a
HF	5.6×10^{-4}
CH_3CH_2COOH	1.3×10^{-5}

A. $HClO < CH_3CH_2COOH < HF < HIO_3$

B. $HClO < HF < CH_3CH_2COOH < HIO_3$

C. $HIO_3 < HF < CH_3CH_2COOH < HClO$

D. $HIO_3 < CH_3CH_2COOH < HF < HClO$

28. Which can describe oxidation?

A. Loss of hydrogen

B. Decrease in oxidation number

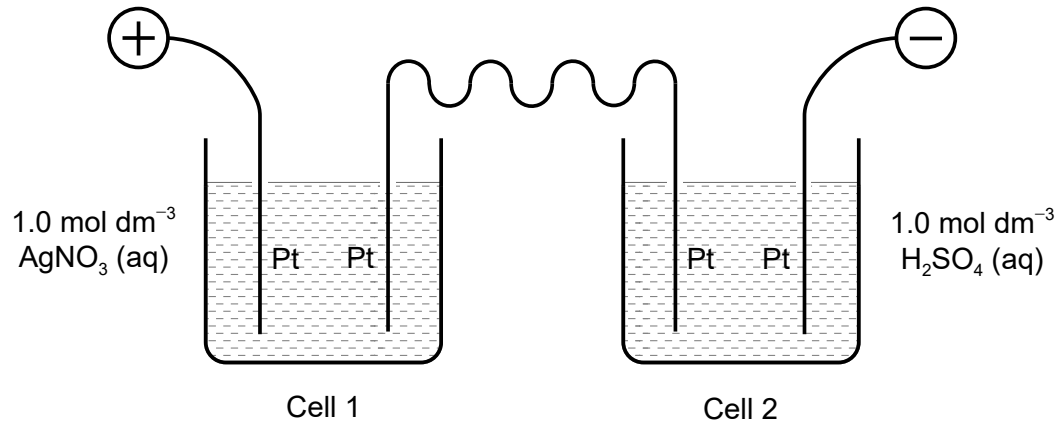
C. Gain of electrons

D. Loss of oxygen

29. What are the products of the electrolysis of molten zinc bromide?

	Negative electrode (cathode)	Positive electrode (anode)
A.	zinc	bromine
B.	hydrogen	bromine
C.	bromine	zinc
D.	bromine	hydrogen

30. Two cells undergoing electrolysis are connected in series.



If x g of silver are deposited in cell 1, what volume of oxygen, in dm^3 at STP, is given off in cell 2?

A_r (Ag) = 108; Molar volume of an ideal gas at STP = 22.7 dm^3 mol^{-1}

A. $\frac{x}{108} \times \frac{1}{4} \times 22.7$

B. $\frac{x}{108} \times 4 \times 22.7$

C. $\frac{x}{108} \times \frac{1}{2} \times 22.7$

D. $\frac{x}{108} \times 2 \times 22.7$

31. What are the major products of electrolysing concentrated aqueous potassium iodide, KI (aq)?

	Negative electrode (cathode)	**Positive electrode (anode)**
A.	potassium	iodine
B.	hydrogen	iodine
C.	hydrogen	oxygen
D.	potassium	oxygen

32. Which compounds belong to the same homologous series?

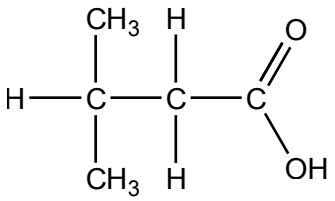
A. $CHCCH_2CH_3$, $CHCCH_2CH_2CH_3$

B. $CH_3CH_2CH_2CH_2OH$, $CH_3CH_2OCH_2CH_3$

C. CH_2CHCH_3, $CH_3CH_2CH_2CH_3$

D. CH_3COCH_3, $CH_3CH_2OCH_3$

33. What is the name of this compound, using IUPAC rules?



A. 1,1-dimethylpropanoic acid

B. 3,3-dimethylpropanoic acid

C. 2-methylbutanoic acid

D. 3-methylbutanoic acid

34. Which are structural isomers?

I. CH_3CH_2OH and CH_3OCH_3
II. $HOCH_2CH_3$ and CH_3CH_2OH
III. CH_3COOH and $HCOOCH_3$

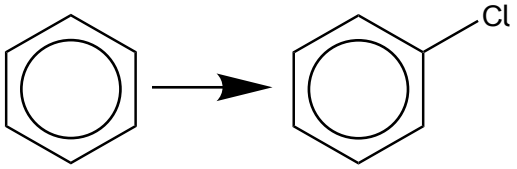
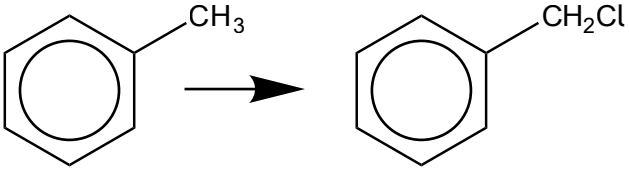
A. I and II only

B. I and III only

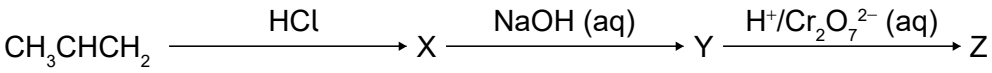
C. II and III only

D. I, II and III

35. Which is the correct combination of substitution reaction mechanisms?

	 **reaction mechanism**	 **reaction mechanism**
A.	electrophilic	free radical
B.	nucleophilic	nucleophilic
C.	free radical	electrophilic
D.	free radical	nucleophilic

36. Propene is reacted first with hydrogen chloride to produce X which is then reacted with aqueous sodium hydroxide to give Y. Finally, Y is reacted with excess acidified potassium dichromate solution.



What is the major product, Z?

A. $CH_3CH(OH)CH_3$

B. CH_3COCH_3

C. CH_3CH_2CHO

D. $CH_3(CH_2)_2COOH$

37. Which isomers exist as non-superimposable mirror images?

A. cis-trans isomers

B. diastereomers

C. enantiomers

D. structural isomers

38. How are the uncertainties of two quantities combined when the quantities are multiplied together?

A. Uncertainties are added.

B. % uncertainties are multiplied.

C. Uncertainties are multiplied.

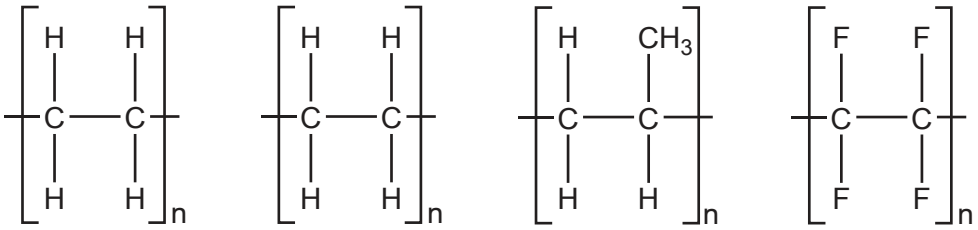
D. % uncertainties are added.

39. The rate of a reaction is studied at different temperatures.

Which is the best way to plot the data?

	***x*-axis**	**Type of variable on *x*-axis**
A.	rate	dependent
B.	rate	independent
C.	temperature	independent
D.	temperature	dependent

40. The IR spectra of low density polyethene (LDPE), high density polyethene (HDPE), polypropene (PP) and polytetrafluoroethylene (PTFE) are shown (not necessarily in that order).



LDPE HDPE PP PTFE

Which spectrum is PTFE?

A.

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B.

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(Question 40 continued)

C.

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D.

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