Anglo-Chinese School
(Independent)

YEAR 6 PRELIMINARY EXAMINATION 2021
INTERNATIONAL BACCALAUREATE DIPLOMA PROGRAMME
CHEMISTRY HIGHER LEVEL

PAPER 1

Monday   **13th September 2021**   **1 hour**

Additional materials:

Multiple choice answer sheet
Soft clean eraser
Soft pencil (type 2B recommended)

INSTRUCTIONS TO CANDIDATES
Do not open this booklet until you are told to do so.
Shade your Candidate number on the multiple choice answer sheet provided.

There are **forty** questions in this paper. Answer **all** the questions. For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in **soft pencil** on the multiple choice answer sheet.

INFORMATION FOR CANDIDATES
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet. A copy of the periodic table is provided for reference on Page 2 of the examination paper.
Calculators are **not** allowed to be used in this paper.

This question paper consists of 17 printed pages, including the cover page.

The Periodic Table

Key:
- Atomic number
- **Element**
- Relative atomic mass

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
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
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
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)
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 **Uuq** (289)	115 **Uup** (288)	116 **Uuh** (293)	117 **Uus** (294)	118 **Uuo** (294)

† Lanthanides:

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

‡ Actinides:

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. 0.10 mol of sulfuric acid is mixed with 0.10 mol of sodium metal.

$$H_2SO_4 \text{ (aq)} + 2Na \text{ (s)} \rightarrow Na_2SO_4 \text{ (aq)} + H_2 \text{ (g)}$$
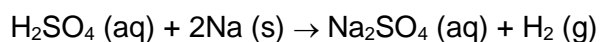
Which is correct?

	Limiting Reagent	Maximum yield of H_2 /mol
A.	H_2SO_4	0.05
B.	H_2SO_4	0.10
C.	Na	0.05
D.	Na	0.10

2. A 100 cm^3 of gas has a pressure of 400 kPa. What would be the new pressure of the gas when the volume of the gas is compressed to half its original volume at constant temperature?

A.   100 kPa

B.   200 kPa

C.   400 kPa

D.   800 kPa

3. Which is correct for $^{79}_{34}Se^{2-}$?

	protons	neutrons	electrons
A.	34	45	34
B.	34	45	36
C.	36	43	32
D.	79	34	36

4. What is the total number of sub-levels that are occupied in a Cr^+ ion?

A.   3

B.   4

C.   6

D.   7

5. Which statements are correct for the emission spectrum of hydrogen?

    I.   The lines converge at higher frequencies.

    II.   Electron transitions to $n = 1$ correspond to the ultraviolet region.

    III.   Lines are produced when electrons move from higher to lower energy levels.

    A.   I and II only

    B.   I and III only

    C.   II and III only

    D.   I, II and III

6. Consecutive elements **X**, **Y** and **Z** are in Period 3 of the Periodic Table. Element **Y** has the highest first ionisation energy and the lowest melting point of these three elements.

What are the identities of **X**, **Y** and **Z**?

    A.   Sodium, magnesium, aluminium

    B.   Magnesium, aluminium, silicon

    C.   Aluminium, silicon, phosphorus

    D.   Silicon, phosphorus, sulfur

7. Sulfur is converted to SF_6 by fluorine, to SCl_2 by chlorine and to S_2Br_2 by bromine.

Which best explains this observation?

    A.   Bond energy of $F_2 < Cl_2 > Br_2$

    B.   Oxidising ability of $F_2 > Cl_2 > Br_2$

    C.   Electronegativity of $F > Cl > Br$

    D.   First ionisation energy of $F > Cl > Br$

8. Which complex is colourless in solution?

    A. $[Fe(H_2O)_6]Cl_2$

    B. $[Ni(NH_3)_6]Cl_2$

    C. $[Zn(H_2O)_6](NO_3)_2$

    D. $K_3[Co(CN)_6]$

9. Which compound contains both covalent and ionic bonds?

    A. NH_4Cl

    B. $MgBr_2$

    C. CH_2Cl_2

    D. CH_3COOH

10. According to VSEPR theory, which molecule would be expected to have the **smallest** bond angle?

    A. H_2O

    B. H_2CO

    C. SiH_4

    D. NH_3

11. Which compound is the most soluble in water?

    A.   Methane

    B.   Propane

    C.   Propan-1-ol

    D.   Pentan-1-ol

12. Which can exist in **both** polar and non-polar forms?

    A. CH_2Cl_2

    B. $C_2H_2Cl_2$

    C. C_2HCl_3

    D. C_2H_3Cl

13. Which statement about the molecule but-2-yn-1-ol is **not** correct?
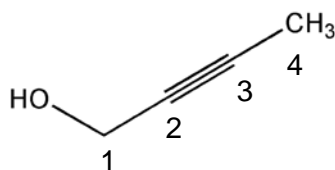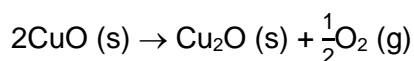

    A.   The centre carbon atoms (2 and 3) are sp hybridised.

    B.   The oxygen atom is sp^3 hybridised.

    C.   The terminal carbon atoms (1 and 4) are sp^2 hybridised.

    D.   The terminal carbon atoms (1 and 4) have tetrahedral geometry.

14. Using the equations below

$$Cu\ (s) + \tfrac{1}{2}O_2\ (g) \rightarrow CuO\ (s) \quad \Delta H^\ominus = -156\ kJ$$

$$2Cu\ (s) + \tfrac{1}{2}O_2\ (g) \rightarrow Cu_2O\ (s) \quad \Delta H^\ominus = -170\ kJ$$
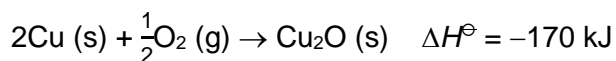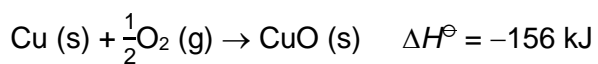
What is the value of $\Delta H^\ominus$ (in kJ) for the following reaction?

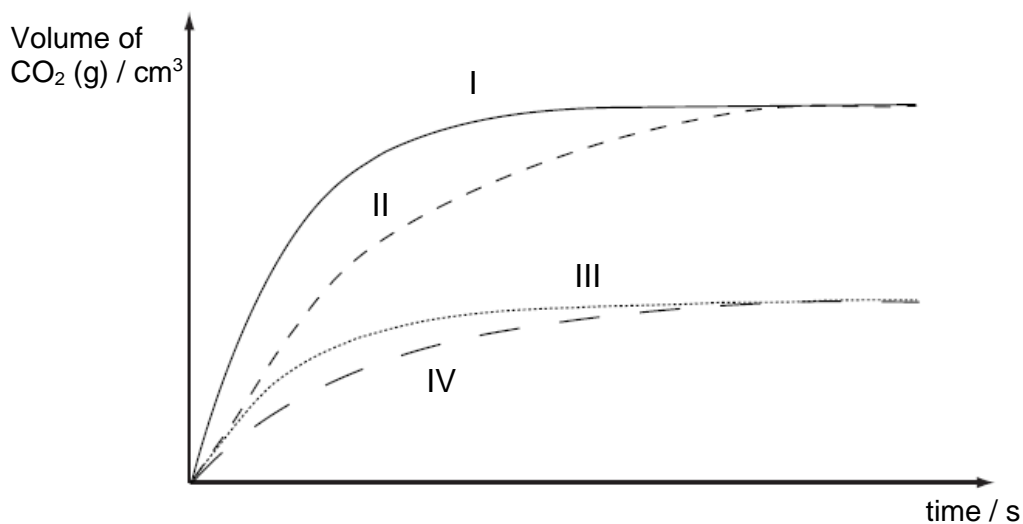$$2CuO\ (s) \rightarrow Cu_2O\ (s) + \tfrac{1}{2}O_2\ (g)$$

    A.   142

    B.   14

    C.   −14

    D.   −142

15. What energy changes occur when chemical bonds are formed and broken?

A. Energy is absorbed when bonds are formed and when they are broken.

B. Energy is released when bonds are formed and when they are broken.

C. Energy is absorbed when bonds are formed and released when they are broken.

D. Energy is released when bonds are formed and absorbed when they are broken.

16. Which equation represents the lattice enthalpy of magnesium oxide?

A. $MgO\ (s) \rightarrow Mg\ (s) + \frac{1}{2}O_2\ (g)$

B. $MgO\ (g) \rightarrow Mg^{2+}\ (g) + O^{2-}\ (g)$

C. $MgO\ (s) \rightarrow Mg^{2+}\ (g) + \frac{1}{2}O_2\ (g)$

D. $MgO\ (s) \rightarrow Mg^{2+}\ (g) + O^{2-}\ (g)$

17. Some chlorine gas is placed in a flask at room temperature and pressure. Which change will cause a decrease in entropy assuming there is no change in temperature and pressure?

A. Adding a small amount of hydrogen

B. Adding a small amount of ethene

C. Adding a small amount of chlorine

D. Exposing the flask to sunlight.

18. Equal masses of powdered calcium carbonate were added to separate solutions of hydrochloric acid. The calcium carbonate was in excess. The volume of carbon dioxide produced was measured at regular intervals.

Which curves best represent the evolution of carbon dioxide against time for the acid solutions shown in the table below?

|	25 cm³ of 2 mol dm⁻³ HCl	50 cm³ of 1 mol dm⁻³ HCl	25 cm³ of 1 mol dm⁻³ HCl
A.	I	III	IV
B.	I	IV	III
C.	I	II	III
D.	II	I	III

19. The diagram shows the energy profile for a catalysed and uncatalysed reaction.

Which represents the enthalpy change, ΔH, and the activation energy, E_a, for the catalysed reaction?

Potential energy

Reaction coordinate
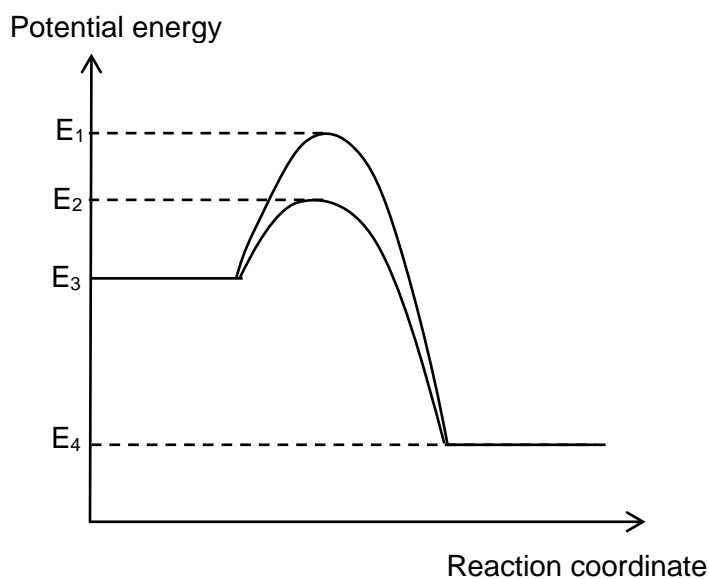
	ΔH	E_a (catalysed reaction)
A.	$E_3 - E_4$	E_1
B.	$E_4 - E_3$	$E_2 - E_3$
C.	$E_4 - E_3$	E_2
D.	$E_4 + E_3$	$E_1 - E_3$

20. Consider the following reaction.

$$NO_2\ (g) + CO\ (g) \rightarrow NO\ (g) + CO_2\ (g)$$
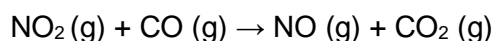
At $T < 227$ °C, the rate expression is rate = $k\,[NO_2]^2$. Which mechanism is consistent with this rate expression?

A. $NO_2 + NO_2 \rightleftharpoons N_2O_4$ *fast*

  $N_2O_4 + 2CO \rightarrow 2NO + 2CO_2$ *slow*

B. $NO_2 + CO \rightarrow NO + CO_2$ *slow*

C. $NO_2 \rightarrow NO + O$ *slow*

  $CO + O \rightarrow CO_2$ *fast*

D. $NO_2 + NO_2 \rightarrow NO_3 + NO$ *slow*

  $NO_3 + CO \rightarrow NO_2 + CO_2$ *fast*

21. The rate constant, k, is commonly described by the Arrhenius equation: $k = A e^{-\frac{Ea}{RT}}$.

Which statements are correct?

I.   A greater E_a value results in a smaller k value.

II.   The A term takes into account the orientation of the reactants.

III.   The slope (gradient) of $\ln k$ against $\frac{1}{T}$ equals E_a.

A.   I and II only

B.   I and III only

C.   II and III only

D.   I, II and III

22.   The decomposition of SO_3 (g) is a reaction in dynamic equilibrium.

$$2SO_3 \text{ (g)} \rightleftharpoons 2SO_2 \text{ (g)} + O_2 \text{ (g)}$$

What happens when the pressure of the system is increased?

A.   The rate of forward reaction will decrease and the position of the equilibrium will shift to the left.

B.   The rate of forward reaction will decrease and the position of the equilibrium will shift to the right.

C.   The rate of forward reaction will increase and the position of the equilibrium will shift to the left.

D.   The rate of forward reaction will increase and the position of the equilibrium will shift to the right.

23. Two compounds **X** and **Y** react to produce compound **Z**. The reaction is reversible.

$$X + Y \rightleftharpoons Z$$

When **X** and **Y** are mixed together in a closed system, a dynamic equilibrium is gradually achieved.

Which graph could represent the change in the rates of the forward and reverse reactions over time?

A.

B.

key

rate of forward reaction

rate of reverse reaction

C.

D.
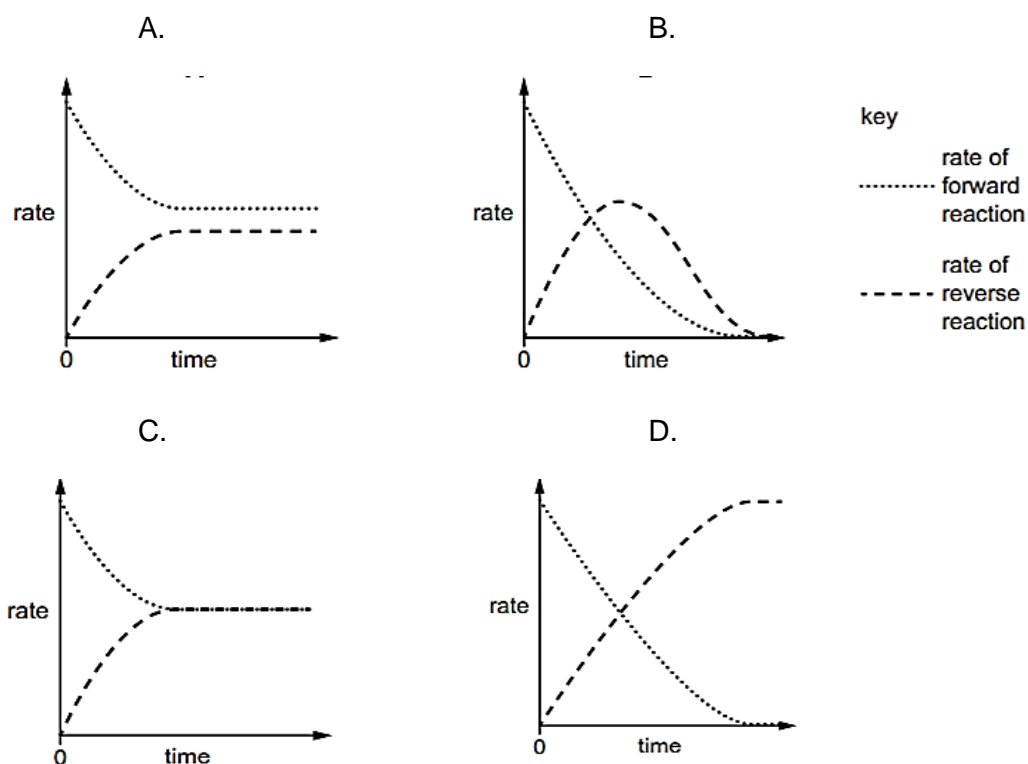
24. The Gibbs free energy change of a system determines whether a reaction is spontaneous, while the equilibrium constant indicates the extent of reaction.

What does the following information for a reaction system indicate?

$\Delta G_r^{\ominus}$ /kJ mol^{-1}	K_c value
−50.8	5.80 x 10^8

A.   No reaction

B.   Position of equilibrium lies to the left

C.   Some extent of forward reaction

D.   Forward reaction goes to completion

25. Which causes the pH of unpolluted rain to be less than 7?

A.　Unburnt hydrocarbons

B.　Carbon dioxide

C.　Nitrous oxides

D.　Sulfur dioxide

26. Which is an example of an amphiprotic species?

A.　MgO

B.　HPO_4^{2-}

C.　SO_2

D.　CO_3^{2-}

27. The dissociation constant, K_w, for the ionisation of water, H_2O (l) $\rightleftharpoons H^+$ (aq) + OH^- (aq), varies with temperature.

temperature / °C	K_w
0	0.1×10^{-14}
25	1.0×10^{-14}

What can be deduced from this information?

A.　$[H^+]$ increases when temperature increases.

B.　The ionisation of water is an exothermic process.

C.　The strength of the hydrogen bonds between water molecules increases with temperature.

D.　$[H^+] < [OH^-]$ at 0 °C.

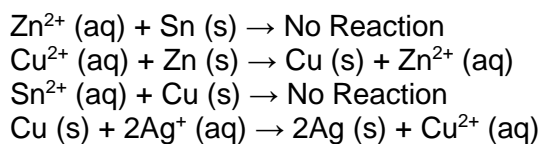**28.** Which of the following will have a pH > 7?

    A.   Aqueous solution of $FeCl_3$

    B.   Equal proportions of ammonium chloride and aqueous ammonia ($pK_b = 4.75$)

    C. 0.0001 mol dm^{-3} of HNO_3 (aq)

    D.   Aluminium oxide in water

29. Which statements are correct for both an electrolytic cell and a voltaic cell?

    I.   The reaction is always spontaneous.

    II.   Electrons always flow from the anode to the cathode.

    III.   Oxidation takes place at the anode.

    A.   I and II only

    B.   I and III only

    C.   II and III only

    D.   I, II and III

**30.** What is the order of increasing reactivity of the metals (least reactive first)?

Zn^{2+} (aq) + Sn (s) → No Reaction
Cu^{2+} (aq) + Zn (s) → Cu (s) + Zn^{2+} (aq)
Sn^{2+} (aq) + Cu (s) → No Reaction
Cu (s) + $2Ag^+$ (aq) → 2Ag (s) + Cu^{2+} (aq)

    A.   Zn < Cu < Sn < Ag

    B.   Sn < Zn < Ag < Cu

    C.   Ag < Cu < Sn < Zn

    D.   Zn < Sn < Cu < Ag

31. What is the standard half-cell potential of copper if the "zero potential reference electrode" is changed from the standard hydrogen electrode to a standard silver/silver chloride electrode?

	$E^{\ominus}$ / V with respect to the standard hydrogen electrode
$Ag^+ (aq) + e^- \rightleftharpoons Ag (s)$	+0.80
$Cu^{2+} (aq) + 2e^- \rightleftharpoons Cu (s)$	+0.34

A.   +0.46

B.   −0.46

C.   +1.14

D.   −1.14

32. What are the relative volumes of gases given off at **E** and **F** during electrolysis of the two cells in series? Assume all electrodes are inert.
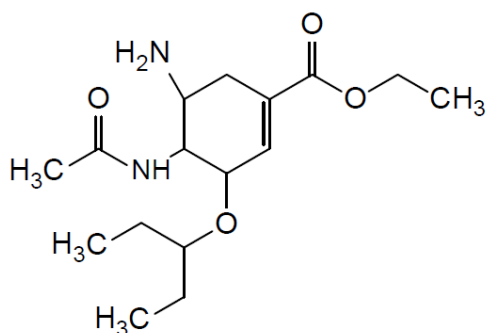

concentrated
aqueous $MgCl_2$

dilute aqueous $MgCl_2$
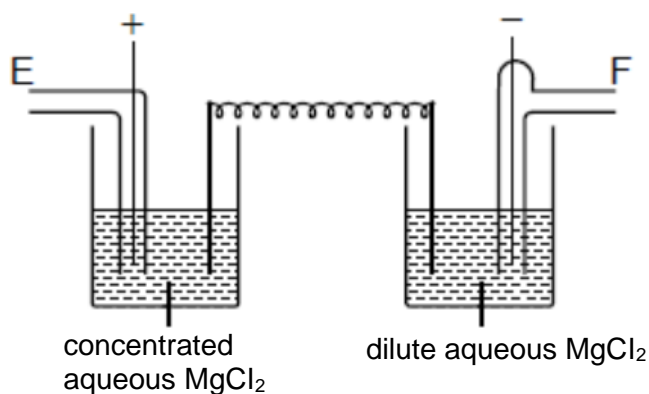
A.   1:1

B.   1:2

C.   2:1

D.   1:4

33. Compound **X** has the molecular formula $C_5H_{12}O$. It reacts with acidified potassium dichromate(VI) to form a substance that turns moist blue litmus paper red.

What could be **X**?

A.   2-methylbutan-2-ol

B.   Pentan-2-one

C.   Ethoxypropane

D.   3-methylbutan-1-ol

34. Which functional groups are present in this molecule?

A. Amine, carbonyl, ether, ester

B. Amine, carbonyl, carboxyl, ether

C. Amine, amide, ether, ester

D. Amine, amide, carboxyl, ether

35. A tertiary bromoalkane, indicated here by $\equiv$C–Br, reacts with aqueous NaOH. The mechanism has the reaction pathway shown.


progress of reaction
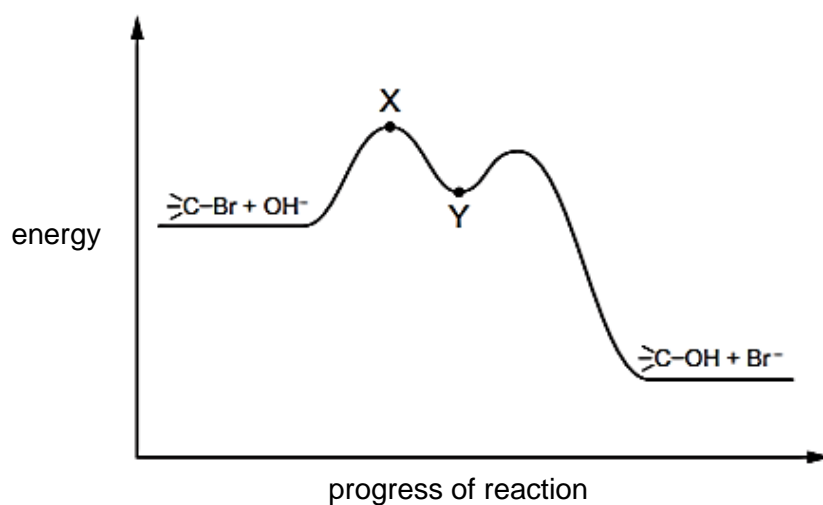
Which point in the diagram is correctly identified?

A. **X** is $\equiv$C+

B. **X** is $\left[\text{HO}\cdots\text{C}\cdots\text{Br} \right]^-$

C. **Y** is $\equiv$C+

D. **Y** is $\left[\text{HO}\cdots\text{C}\cdots\text{Br} \right]^-$

**36.** Which of the following statements is correct about the stereoisomerism shown by 2,4-dimethylhex-2-ene?

A. 2,4-dimethylhex-2-ene has 2 cis-trans isomers and 2 enantiomers.

B. 2,4-dimethylhex-2-ene has 2 cis-trans isomers only.

C. 2,4-dimethylhex-2-ene has 2 enantiomers only.

D. 2,4-dimethylhex-2-ene have neither cis-trans isomers nor enantiomers.

37. What is the IHD, index of hydrogen deficiency, of this nitrogenous base, guanine?
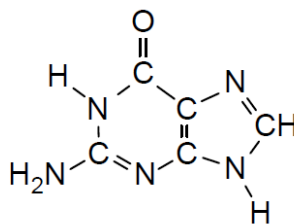
A. 3

B. 4

C. 5

D. 6

38. Which compound gives the low resolution ^{1}H NMR spectrum below?
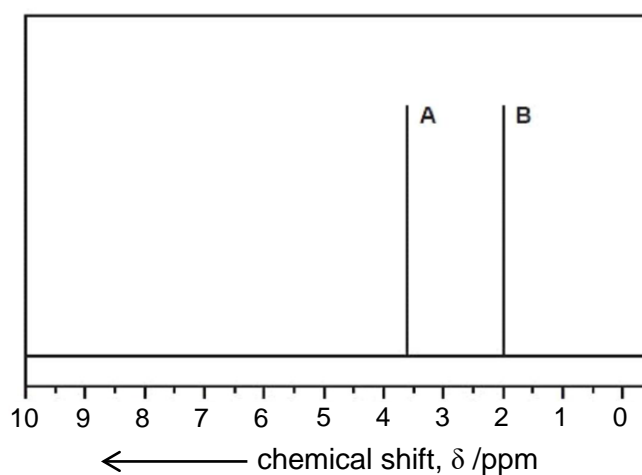
A. CH_3CH_2COOH

B. CH_3COOCH_3

C. $HCOOCH_2CH_3$

D. $CH_3CH(OH)CH_2OH$

39. Which of the following cannot be determined by the X-ray crystallography technique?

    A. Relative molecular mass

    B. 3-D configuration

    C. Bond length

    D. Bond angle

40. How are the uncertainties of two quantities combined when the quantities are involved in a subtraction?

    A. Absolute uncertainties are added.

    B. % uncertainties are multiplied.

    C. Absolute uncertainties are multiplied.

    D. % uncertainties are added.

End of Paper