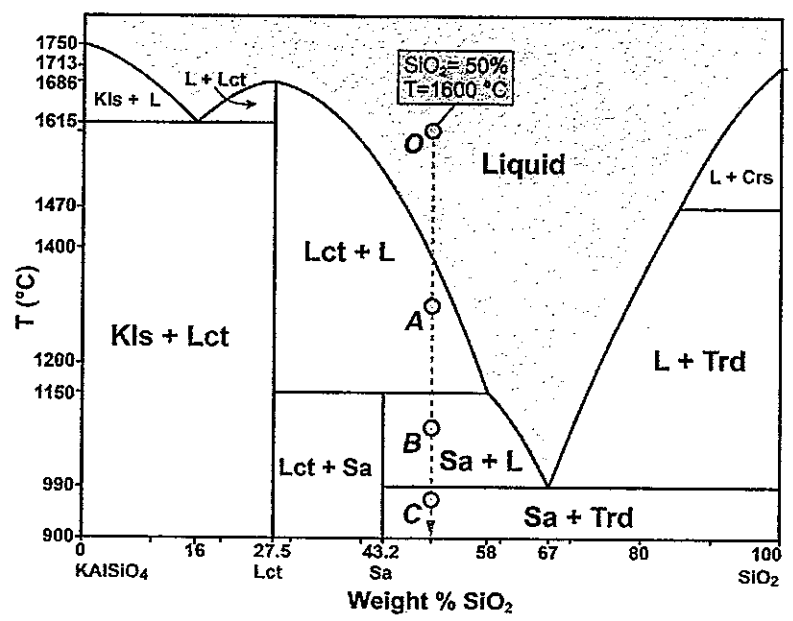
**A. 名詞解釋【每小題 3 分，合計 33 分】**

1. diamagnetic 2. refractive index 3. secondary twin 4. stishovite 5. crystal habit 6. aphanitic
7. CIPW norm 8. geobarometer 9. schist 10. shale 11. stylolite

**B. 問答題【共 5 小題，合計 47 分】**

1. 下圖為六方鉀霞石與二氧化矽的溫度—兩成份相圖，圖中虛線箭頭表示一股封閉系統中成分為 50 % $SiO_2$ 的岩漿從 1600°C (*O* 點)開始的降溫路徑。請回答與之相關的以下三題。【每小題 5 分，共 15 分】




(1) 岩漿降溫至 1300°C（*A* 點）時，有哪些相並存？各相的化學成分為何？各相佔多少重量百分比（wt.%）？
(2) 岩漿降溫至 1100°C（*B* 點）時，有哪些相並存？各相的化學成分為何？各相佔多少重量百分比（wt.%）？
(3) 岩漿降溫至 975°C（*C* 點）時，有哪些相並存？各相的化學成分為何？各相佔多少重量百分比（wt.%）？

2. 以下為岩石中可見的組構(texture)，試分別簡述其特徵，並說明其成因或地質上的意涵。【每小題 5 分，共 10 分】
(1) porphyroblast (2) phenocryst
3. 說明隱沒帶岩漿弧的岩漿成因。【6 分】
4. 描述在河流中碎屑顆粒是如何被搬運的。【8 分】
5. 分別闡述 (1) 溫度與 (2) 壓力在變質作用中對岩石、礦物所造成的影響。【8 分】

**C. 礦物資料閱讀題【每小題 2 分，合計 20 分】**請根據下一頁摘自礦物手冊的資料，回答以下關於 Biotite 的十小題。

1. Biotite 的中文名稱是什麼？其化學式為何？
2. Biotite 的屬於哪一個晶系？常見晶形外觀有哪些？
3. Biotite 屬於哪個點群？哪個空間群？
4. Biotite 的比重是多少？硬度是多少？
5. Biotite 有哪一個方向的解理？
6. Biotite 有哪些良好晶體的產地？請列兩處。
7. Biotite 在偏光顯微鏡下的光學類型為何？多色性是強或弱？
8. Biotite 的條痕顏色為何？解理面上的光澤為何？
9. Biotite 的成礦環境與方式有哪些？請列出兩種，只寫岩性以零分計。
10. Biotite 的名稱來源？

見背面

## Biotite $K(Mg,Fe^{2+})_3(Al,Fe^{3+})Si_3O_{10}(OH,F)_2$



**Crystal Data:** Monoclinic. *Point Group:* $2/m$. Uncommon in good crystals, tabular or short prismatic, with pseudohexagonal outline, to 3 m. Typically irregular foliated or bent masses; in scaly aggregates or disseminated grains. *Twinning:* On composition plane {001}, twin axis [310].

**Physical Properties:** *Cleavage:* {001}, perfect. *Tenacity:* Brittle to flexible, elastic. Hardness = 2.5–3 D(meas.) = 2.7–3.3 D(calc.) = 3.25

**Optical Properties:** Semitransparent. *Color:* Dark green, brown, black, reddish brown, light yellow, grayish yellow, brownish green, brown; yellow to reddish brown in thin section. *Streak:* White. *Luster:* Splendent to submetallic, vitreous, pearly on cleavage. *Optical Class:* Biaxial (–). *Pleochroism:* Strong; $X$ = gray-yellow, yellow-brown, orange-brown; $Y = Z$ = dark brown, dark green, dark red-brown. *Orientation:* $Y = b$; $X \wedge c = 0°$–$3°$; $Z \wedge a = 0°$–$9°$. *Dispersion:* $r < v$, Fe-rich; may be $r > v$, Mg-rich; weak. *Absorption:* $Y \simeq Z \gg X$. $\alpha = 1.565$–$1.625$ $\beta = 1.605$–$1.696$ $\gamma = 1.605$–$1.696$ 2V(meas.) = 0°–25°

**Cell Data:** *Space Group:* $C2/m$. $a = 5.3$ $b = 9.2$ $c = 10.2$ $\beta = 100°$ Z = 2

**X-ray Powder Pattern:** Edenville, Orange Co., New York, USA.
10.1 (100), 3.37 (100), 2.66 (80), 2.45 (80), 2.18 (80), 2.00 (80), 1.67 (80)

**Chemistry:**

| | (1) | | (1) | | (1) |
|---|---|---|---|---|---|
| $SiO_2$ | 36.25 | MnO | 0.49 | $K_2O$ | 9.57 |
| $TiO_2$ | 3.39 | MgO | 11.80 | Cl | 0.06 |
| $Al_2O_3$ | 13.90 | CaO | 0.00 | $H_2O^+$ | 2.80 |
| $Fe_2O_3$ | 6.80 | $Li_2O$ | 0.03 | Total | 100.00 |
| FeO | 14.81 | $Na_2O$ | 0.10 | | |

(1) Vercelli, Italy; by electron microprobe, average of six analyses on one grain, $Fe^{3+}$ by a semimicrovolumetric method, $H_2O$ by TGA; corresponds to $(K_{0.94}Na_{0.02})_{\Sigma=0.96}(Mg_{1.35}Fe^{2+}_{0.95}Mn_{0.03})_{\Sigma=2.33}(Fe^{3+}_{0.39}Ti_{0.20}Al_{0.05}Li_{0.01})_{\Sigma=0.65}(Si_{2.79}Al_{1.21})_{\Sigma=4.00}[O_{10.55}(OH)_{1.44}Cl_{0.01}]_{\Sigma=12.00}$, in the general structural formula $K(Mg,Fe^{2+})_{3-2}(Al,Fe^{3+},Ti)_{0-1}(Si_{3-2.5}Al_{1--1.5})_{\Sigma=4}O_{10--11}(OH,F)_{2--1}$.

**Polymorphism & Series:** 1M, $2M_1$, 3A polytypes.

**Mineral Group:** Mica group.

**Occurrence:** An important rock-forming mineral under a wide range of conditions. In regionally metamorphosed schists and gneisses, and in contact metamorphosed rocks; in granites to nepheline syenites; less common in extrusive igneous rocks, from rhyolites to basalts. Characteristic of potassic hydrothermal alteration; in detrital sediments.

**Association:** Quartz, potassic feldspar, plagioclase, nepheline, muscovite, pyroxenes, amphiboles, andalusite, cordierite, garnet, spinel.

**Distribution:** Good crystals from: in Italy, at Vesuvius and Monte Somma, Campania, and in the Pfitschtal and on Mt. Monzoni, Val di Fassa, Trentino-Alto Adige. At Brevik and Arendal, Norway. From near Miass, Ilmen Mountains, Southern Ural Mountains, Russia. In the USA, from Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey; Monroe, Orange Co., and Russell, St. Lawrence Co., New York; at Easton, Northampton Co., Pennsylvania; from the Pala and Rincon districts, San Diego Co., California. In Canada, in Ontario, at Bancroft, Wakefield, and Otter Lake, Parry Sound; in Quebec, in the Bear Lake mine, Pontiac Co.

**Name:** For the French mineralogist and physicist, Jean Baptiste Biot (1774–1862).