

※注意：請於試卷上依序作答，並應註明作答之部份及其題號。

第一部份 (50%)

科目名稱：地球物質 (礦物部份共50分)

一、【解釋名詞，每題5分，共10分】

- (1) cleavage (2) stereographic projection

二、【簡答題，共20分】：下列是摘自礦物學課本對Tourmaline礦物之描述性資料，請在詳細閱讀後按照題號簡單回答本題的10個小題。

TOURMALINE—(Na,Ca,□)(Fe²⁺,Mg,Al,Mn,Li)₃(Al,Fe³⁺)₆(BO₃)₃(Si₆O₁₈)(OH)₃(OH,F,O)

Crystallography. Hexagonal; 3m. Usually in prismatic crystals with a prominent trigonal prism and subordinate hexagonal prism, $\{11\bar{2}0\}$, vertically striated. The many different (*hkil*) prism faces may round into each other giving the crystals a cross section like a spherical triangle. When doubly terminated, crystals usually show different forms at the opposite ends of the vertical axis due to the polar nature of the structure (Fig. 19.34). May be massive, compact; also coarse to fine columnar, either radiating or parallel.

$R3m$; $a = 15.95$, $c = 7.24$ Å; $Z = 3$. ds : 4.24(7), 4.00(7), 3.51(7), 2.98(9), 2.58(10).

Physical Properties. H 7–7½. G 3.0–3.25. *Luster* vitreous to resinous. *Color* varied, colorless, pink, green, blue, brown, black, depending on the composition and cannot necessarily be correlated with individual species. *Fracture* conchoidal.

Fe-bearing tourmaline (*schorl*) is most common and is usually black; *dravite* contains Mg and is usually brown. The rarer Li-bearing varieties (*elbaite*, containing Na and *liddicoatite*, containing Ca) are light colored in fine shades of green, yellow-red-pink, and blue; see Plate V, no. 6. Rarely white or colorless *rossmanite*. A single crystal may show several different colors arranged either in concentric envelopes about the c axis or in layers transverse to the length. Strongly pyroelectric and piezoelectric. *Optics*: (-); $\omega = 1.635$ –1.675, $\epsilon = 1.610$ –1.650. Some varieties are strongly pleochroic, $O > E$.

Composition and Structure. A complex silicate of B and Al (see Fig. 18.14) with the following substitutions: Ca for Na along the centers of the ring channels; Mg and Al for Li in 6-coordination between Si₆O₁₈ rings and BO₃ groups; Fe³⁺ and Mn³⁺ for Al in polyhedra that link the Si₆O₁₈ rings.

Diagnostic Features. Usually recognized by the characteristic rounded triangular cross section of the crystals and conchoidal fracture. Distinguished from hornblende by absence of cleavage and the presence of striated prisms.

Occurrence. The most common and characteristic occurrence of tourmaline is in granite pegmatites (see Box 19.5) and in the rocks immediately surrounding them. It is found also as an accessory mineral in most igneous and metamorphic rocks. It is stable from low temperatures and pressures to very high temperatures and pressures. Most pegmatitic tourmaline is *schorl* or *elbaite* and is associated with the common pegmatite minerals, microcline, albite, quartz, and muscovite. Pegmatites are also the home of the light-colored lithium-bearing tourmalines frequently associated with lepidolite, beryl, apatite, fluorite, and rarer minerals. Mg-rich tourmaline is found in marbles and schists. Occurs as a detrital mineral in sediments due to its mechanical and chemical stability.

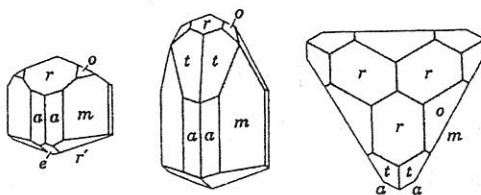
Famous localities for the occurrence of the gem tourmalines are the Island of Elba, Italy; the state of Minas Gerais, Brazil; Ural Mountains near Sverdlovsk, Russia; and Madagascar. In the United States, found at Paris and Auburn, Maine; and Mesa Grande, Pala (Fig. 19.35), Rincon, and Ramona in San Diego County, California. Brown crystals are found near Gouverneur, New York, and fine black crystals at Pierrepont, New York.

Use. Tourmaline forms one of the most beautiful of the gemstones (see Plate X, no. 11, Chapter 20). The color of the stones varies, the principal shades being olive-green, pink to red, and blue. A copper-bearing variety is bright turquoise. Sometimes a stone is cut to show different colors in different parts. The green-colored stones are usually known by the mineral name, tourmaline. The red or pink stones are known as *rubellite*, and the rarer dark blue stones are called *indicolite*.

Because of its strong piezoelectric property, tourmaline is used in the manufacture of pressure gauges to measure transient blast pressures (for piezoelectricity, see page 35). Its wide P - T stability field and sensitivity to original chemical environment allows tourmaline to be used as a provenance indicator mineral in sediments and their metamorphic equivalents.

Name. *Tourmaline* comes from *turamali*, a name given to the early gems from Sri Lanka.

FIG. Tourmaline crystals.



1. Tourmaline的中文名稱是什麼？是屬於哪一種矽氧四面體結構的矽酸岩類？

見背面

2. *Tourmaline*化學式中的□是什麼元素或代表什麼意思？
3. *Tourmaline*的結晶構造屬於哪一個晶系？哪一個晶族？哪一個空間群？
4. *Tourmaline*的折射率最高是多少？最高的雙折射率是多少？
5. *Tourmaline*具有什麼解理？Mohs hardness是多少？
6. *Tourmaline*的比重是多少？最強的X光繞射峰的晶面間距是多少Å？
7. *Tourmaline*的光澤，以中文來說是什麼光澤？
8. *Tourmaline*最常產於哪一種岩石之中？列出兩種最常出現在偉晶岩中屬於*Tourmaline*類礦物的英文名稱？
9. *dravite*最常產於哪兩種岩石之中？
10. *Tourmaline*的名字是從哪個字而來的？這個字原本指什麼東西？

- 三、(1) 請寫出礦物六大晶系中除了等軸晶系以外晶系的中英文名稱【5分】
 (2) 請寫出上述五大晶系的定義。(即a,b,c軸的關係與 α,β,γ 角的關係)【5分】
- 四、(1) 請簡單畫出橄欖石在高溫部分(1000°C以上)的相圖，橫軸為成分，縱軸為溫度。已知鎂橄欖石的熔點為1890°C，鐵橄欖石的熔點為1205°C，而且二者是橄欖石完全固溶體的兩個端成分。請清楚標示出橫軸、縱軸與各相名稱。【6分】
 (2) 請用「相律」計算在理論上此系統中最多(即當自由度為零時)可以出現幾相共存？實際相圖中最多只有幾相共存？(令F代表自由度，c代表成分，p代表相)【4分】

第二部份 (50%)

科目名稱：地球物質 (岩石部份共50分)

一、【解釋名詞，每題5分，共30分】：

- | | | |
|-------------------|---------------|------------------|
| (1) asthenosphere | (2) sandstone | (3) metamorphism |
| (4) granite | (5) solidus | (6) lherzolite |

二、【簡答題，共20分】：

- (1) 請比較(a)中洋脊(b)隱沒帶兩種板塊構造環境的岩漿成因。【8分】
- (2) 何謂變質相(metamorphic facies)？請繪圖舉例說明。【8分】
- (3) 請描述澎湖群島的主要岩石組成和成因。【4分】

試題隨卷繳回