

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION

12 September 2023 (am)

Subject CM1 – Actuarial Mathematics Core Principles

Paper B

Time allowed: One hour and fifty minutes

In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator.

If you encounter any issues during the examination please contact the Assessment Team on T. 0044 (0) 1865 268 873.

- 1** An investor is liable to income tax at 22% (payable 3 months in arrears) and capital gains tax at 27% (payable 5 months in arrears).

A security, which pays coupons every 6 months in arrears at a rate of 3.75% p.a., has just been issued at a price of \$100 per \$100 nominal. It is to be redeemed at \$103.50 per \$100 nominal on a coupon date between 15 and 20 years after the date of issue. The date of redemption is at the option of the borrower.

Calculate the minimum net effective yield the investor would achieve if they purchased the security and held it until redemption. [16]

- 2** The annual effective forward rate applicable over the period t to $t + r$ is defined as $f_{t,r}$, where t and r are measured in years. A set of discrete time forward rates is given on the 'Q2 Base' worksheet.

(i) Derive the 1-year spot rates for time periods 1 to 25 inclusive. [4]

(ii) Explain, briefly, one possible justification for the shape of the (spot rate) yield curve. [3]

(iii) Calculate the 20-year par yield. [3]

A 20-year bond redeemable at par is issued with coupons equal to the par yield calculated in part (iii) at a price of £99 per £100 nominal.

(iv) Calculate the yield to maturity. [4]

[Total 14]

- 3** An insurance company offers a 25-year with-profit endowment assurance. The death benefit is payable immediately on death. Premiums are payable annually in advance.

The company offers two policy options:

- conventional with profits
- unitised with profits.

The assumptions used to profit test are listed on the 'Q3 Base' worksheet.

(i) Calculate the benefit payable on death during each year of the policy under each policy option. [19]

(ii) Calculate the maturity benefit payable under each policy option. [2]

[Total 21]

4 An analyst is investigating the historic mortality experience of a life insurance company. The analyst has been given the claims experience data for the following portfolio of policies sold on 1 January 2008:

- 15-year term assurance policies, with a total sum assured of \$12.8 million, issued to a group of lives aged 32 exact at outset. Death benefits were paid immediately on death. Premiums were paid annually in advance.
- Temporary level annuities, with a total annual annuity benefit of \$640,000, issued to a group of lives aged 67 exact at outset with a term of 15 years. A single premium was paid at outset and the annuity payments were made annually in arrears.

The worksheet 'Q4 Base' sets out this claims data as well as the pricing and reserving assumptions used by the company.

- (i) Calculate, for both policy types, the total premium received in the first year of the policy. [16]
 - (ii) Calculate, using the actual mortality experience, the reserve held at the end of each policy year for both policy types. [11]
 - (iii) Calculate the total mortality profit or loss, accumulated to 1 January 2023, experienced by the company over the 15-year term for this portfolio of policies. [16]
 - (iv) Comment, without performing any further calculations, on the mortality experience of the company for this portfolio of policies. [6]
- [Total 49]

END OF PAPER